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The Safety Culture Indicator Scale Measurement System (SCISMS)

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16. Abstract
This document describes an integrated method for the assessment of safety culture in Part 121 aviation operations. This technique has been developed with research support received from the Federal Aviation Administration's William J. Hughes Technical Center. The objective of this research has been to develop, test, and validate the feasibility of measuring the culture of safety in commercial aviation operations. The Safety Culture Indicator Scale Measurement System is part of an ongoing government, industry, and academic research endeavor to further address system development, user needs, and tool refinement for the various stakeholders in the aviation industry as they utilize ATOS and transition to Safety Management Systems. The foundation of this research in safety culture employs a sociotechnical systems approach recognizing the complex relationship between the regulatory and organizational systems, and the purposeful interaction between people, environment, and technology embedded within these systems. The outcome of this research is a well-vetted measurement system that has provided consistent, meaningful information about the culture of safety within an organization, from the initial baseline evaluation to re-evaluation of any changes or progress in the culture, taking consideration of its working groups, as well as standardized information for the comparison of safety cultures across the aviation industry as a benchmarking tool.

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LIST OF ACRONYMS

AFS	Flight Standards Service
AQP	Advanced Qualification Program
ASAP	Aviation Safety Analysis Program
CASS	Commercial Aviation Safety Survey
FAA	Federal Aviation Administration
FOQA	Flight Operations Quality Assurance
JAA	Joint Aviation Authority
ICAO	International Civil Aviation Organization
LOSA	Line Operations Safety Audit
SASO	Systems Approach for Safety Oversight
SCISMS	Safety Culture Indicator Scale Measurement System
SMS	Safety Management System
SOP	Standard Operating Procedure
US	United States

EXECUTIVE SUMMARY

This document describes an integrated method for the assessment of indications of safety culture in Part 121 aviation operations. This technique has been developed with research support received from the Federal Aviation Administration's (FAA) William J. Hughes Technical Center Flight Safety Branch, AJP-6350, in support of Flight Standard Services (AFS) to develop risk-informed oversight capabilities. As risk measures and areas of acceptable risk have been previously defined under the FAA's research agenda (RPD-676), the objective of this research has been to increase the transparency of the concept of organizational safety culture through developing, testing, and validating the feasibility of measuring the culture of safety in commercial aviation operations, beginning with Part 121 air carriers. The approach outlined in this document is part of an ongoing research endeavor to address system development, user needs, and tool refinement for stakeholders in the aviation industry. The foundation of this research employs a sociotechnical systems approach recognizing the complex relationship between regulatory and organizational systems, and the purposeful interaction between the people, environment, and technology embedded within these systems. Thusly, we provide an applicable tool as well as actionable information for stakeholders who must design achievable strategies for industry compliance.

In this report, we offer an introduction to the basic background theory behind safety culture, we would be remiss not to; however, this document is not a tome on the history safety culture or its manifestations. In the text we refer to our previous studies, and those of our colleagues, tracing and defining the concept of safety culture. Rather, this document serves to familiarize the reader with the measurement construct and describes the evaluation of techniques to support the assessment of organizational safety culture, here specifically for Part 121 aviation operations. This approach fuses techniques to measure both the organizational safety culture and the professional safety climate at an organization. This research was conducted using the Safety Culture Indicator Scale Measurement System (SCISMS) developed at the University of Illinois at Urbana Champaign, and engaged voluntary assistance from commercial air carriers who served as test organizations. Also presented within this report is an overview of data results collected using the SCISMS in Part 121 operations. The International Civil Aviation Organization (ICAO) has identified a number of areas in which certain elements of aviation safety programs may be further supported and enhanced, through Safety Management Systems (SMS). One important tenet of SMS is the attention to organizational safety culture. As US aviation organizations move toward the regulation of Safety Management Systems (SMS), it is recommended they make use of the SCISMS survey as a baseline measure of their organization's safety culture, thus obtaining a measure upon which to judge critical movement and change in the organization's culture of safety. The SCISMS approach is flexible and consistent. Survey items can be varied to capture the specific conditions of each operational unit, but the overall framework remains constant. This means that individual departments or units can receive detailed, specific feedback (rather than feedback based on a set of broad, one-size-fits all items), but the overall results are presented in a common language to facilitate comparisons. This approach has allowed organizations to be studied over time and compared across operations. Using a consistent framework to measure safety culture then allows for comparisons across aviation organizations for industry benchmarking as a whole.

1. INTRODUCTION.

In aviation, as in other high reliability, safety critical systems, it is understood errors are inevitable. In prior decades, human error has been considered a root cause of accidents in complex systems. As the study of accident causation and human error has advanced, the active failures of front line operators have become considered outcomes of latent system deficiencies (e.g., Reason 1990, 1997). To understand conditions that yield errors, it is necessary to evolve beyond the limited scope of tracing the erroneous actions of individuals. For every observed error in a system, countless undetected hazards or failures lie in wait to breach the system's defenses. Thus research has focused on reducing the adverse effects of error on the outcome of a system breach by producing meticulously developed tools, technologies, procedures, and redundancies to provide buffers in a system to incorporate error tolerance.

With modern aviation operations growing ever more complex in times of increased demand for services with decreased resources, organizational factors and regulatory oversight play significant roles in the foundation of safety in high-risk systems. Several high profile accidents in the late twentieth century brought considerable attention to the role of organizational factors and regulatory oversight in accident causation (von Thaden, Wiegmann & Shappell, 2006; Wiegmann, Zhang, von Thaden, Gibbons, & Sharma, 2004). Accordingly, the FAA's Systems Approach for Safety Oversight (SASO) was established to provide a comprehensive, integrated procedure to encompass a national standard of system safety involving regulation and oversight of commercial aviation organizations. While the aviation organizations must provide for safety within their organizations, the FAA, through SASO, ensures that the organizations comply with their safety responsibilities (FAA, 2008). Key data gathering areas for identification, analysis, and prioritization of information to mitigate hazards and risks and promote opportunities include: procedures/processes, people, technology, regulations/guidance, facilities, materials, tools, equipment, and performance management.

As aviation organizations strive to maintain economic viability in a varied global environment they must continually modify their business processes and even their workforce to provide services in times of accelerated aviation activity paired with diminishing resources. While it may be strategically advantageous to reengineer business processes from time to time in order to remain vitally functional, ongoing and updated safety efforts must not be overlooked. As the aviation industry continues to change, safety efforts must also remain a business priority. For example, high fuel costs have increased the airlines' overhead. In order to control costs, many airlines have had to schedule fewer flights; as a result this has also sacrificed revenue. In fact, the ten largest airlines in the United States (US) posted a combined loss of $11.76 billion as of June, 2008, due largely to high fuel prices (Karp, 2008). While there are a number of economic concerns that may influence an airline's prioritization of the culture of safety, a difficult economic situation may lead an airline to redirect resources away from functions that are essential to safe operations (Rose, 1991), thus pushing the limits of the current state of safety.

Managing safety has become increasingly more important as aviation organizations diversify. Thus aviation has adopted Safety Management Systems (SMS) to espouse a quality management approach to complex aviation safety and business relationships (FAA, 2006; ICAO, 2006). SMS provides an organizational framework to effectively manage safety and serves as the very structure that generates a positive safety culture. SMS frameworks have shown effectiveness when not only adopted as part of a business, but when adopted as part of regulatory oversight operations as well. As the FAA establishes requirements for US aviation certificate holders to implement SMS, continued research into proactive organizational safety culture provides a better understanding of organizational performance, accountabilities, policies and procedures surrounding safety. However, at the dawn of this new oversight relationship the concession between aviation organizations and regulatory authorities must consider the nature and amount of information required to allow the regulatory authorities minimal policing yet optimal influence over organizational safety. Adding to the well-known collection of voluntary self-assessment tools advocated by the FAA as complementary to traditional regulatory requirements (e.g., Advanced Qualification Programs (AQP), Aviation Safety Analysis Programs (ASAP), Flight Operations Quality Assurance programs (FOQA), and Line Operations Safety Audit (LOSA) etc.), the Safety Culture Indicator Scale Measurement System (SCISMS) serves as an organizational self-assessment instrument designed to aid operators in measuring indicators of their organization's safety culture, targeting areas that work particularly well and areas in need of improvement. After collection of data and analysis of safety culture information, organizations may then further evaluate and strategize about the findings to implement best practices for their operation, thus permitting the highest probable safety outcome.

1.1 PURPOSE.

The purpose of this document is to demonstrate a scientifically-based, psychometrically rigorous framework developed as a benchmarking tool for aviation industry, demonstrated in this document for US Part 121 and similar (e.g., foreign counterparts) organizations.

The methodology discussed here demonstrates an approach to identify and analyze the indicators of an organizations' safety culture fused with indicators of its safety climate that go beyond traditional methods, integrating both quantitative and qualitative information including information associated with organizational, human, technical, physical, and regulatory aspects of the aviation system. This instrument is not meant as a standalone process, but rather serves as a flexible measure to capture complex system relationships revealing industry best practices and potential system hazards, when used in concert with SMS.

2. BACKGROUND.

Great progress has been made to significantly reduce the rate of aviation accidents over the past 50 years through advances in engineering, training, selection, and other scientific interventions. Yet in recent decades, the significant reductions realized earlier have come to a near standstill. The reported rate of commercial aviation accidents, due at least in part to human error has remained constant at ~80% (Kern, 2001; Wiegmann & Shappell, 2003). The exploration of accident cause factors due to human error is gaining maturity and has been integral providing detailed analysis of the causes of accidents so that we may learn. These efforts have, among others, lead to the improved efficient training of air crews in such areas a multi crew pilot licenses, for example (JAA, 2006). But if we are to promote the continued reduction of the accident rate due to human error, the coordination of systematic organizational safety efforts must accelerate. Accident research has shown that the human failure of the front line operator, in many accidents, represents only a superficial cause (cf. Reason, 1990; Helmreich & Merritt, 1998; Wiegmann & Shappell, 2003; von Thaden, et. al, 2006). An active failure is considered unsafe behavior, which influences the direct safety of the system. Upon close analysis, the errant human behavior often derives from external, underlying factors that have propagated through the system over a period of time. For example, technical advances, such as an electronic flight bag, have upon occasion not contained critical data needed for an approach, but this is only revealed to the cockpit crew in the act of performing the maneuver. These latent errors experience a time delay between when the error was generated to its emergence. Latent defects tend to reveal themselves coupled with other active faults, linking together to result in an accident with far greater consequences than would have resulted from an errant behavior alone.

Safety and reliability are the basis upon which commercial airlines provide services worldwide. The safety standard in commercial aviation today is exceptionally high. Incidents or accidents, circumstances in which persons or materials suffer damage, in commercial aviation are relatively rare due to the diversity and complexity of the supplementary technical and organizational processes put in place to assuage them. Safety risks are largely minimized through the thorough review of the aircraft on the ground, the attention to permanent airworthiness documentation, the redundancy of systems, sophisticated equipment and procedures, and the safety behaviors of the workers. With this in mind, air traffic globally is forecast to continually and steadily increase operations over the next two decades. Projections indicate that the world's passenger traffic will increase 4.9% annually, nearly tripling that of today by circa 2026 (ACI, 2007; Doran, 2008). Needless to say, the objective of minimizing disruption and incidents during this growth period will most likely be achieved if the absolute number of disturbances remains constant or declines. Latent factors then must be explored through the lens of the organization and its multifaceted operations if the level of accidents is to be reduced.

In their investigation of organizational factors in aviation accidents, von Thaden, Wiegmann, and Shappell, (2006), uncovered problems in the operational procedures and guidelines for large and small operators alike. Among the organizational shortcomings revealed, smaller operations demonstrated problems in the areas of training, leadership and quality control as prominent, while in the larger (major) airlines, these problems shifted to also include the exchange of information, communication and documentation. With an understanding of these types of organizational underpinnings leading to error in commercial aviation, the culture of organizations where such problematic areas persist remain a central focus in seeking solutions to mitigate safety problems. The International Civil Aviation Organization (ICAO) has identified a number of areas in which certain elements of aviation safety programs may be further supported and enhanced, through Safety Management Systems (SMS). One important tenet of SMS is the attention to organizational safety culture.

2.1 Organizational Safety Culture.

While organizational loss factors and administrative responsibility have been in the industrial safety literature for years (e.g., March & Simon, 1958; Heinrich, 1959), the idea that organizations create working environments that promote or inhibit safety is relatively new. Dov Zohar, an industrial/organizational psychologist, proposed the notion of "safety climate" in 1980, and the term "safety culture" first appeared in the analysis of the Chernobyl disaster in 1986 (Cox & Flin, 1998; see Section 2.1.1 below). From Zohar's 1980 study until 2000, only about two dozen safety climate studies were published (von Thaden & Gibbons, 2007). In the past eight years, however, the research field has grown remarkably[1]. Safety culture/climate studies are conducted in such diverse domains as industrial/organizational psychology (e.g., Wallace and Chen, 2006; Zohar, 1980, 2000), risk management (e.g., Cox and Cheyne, 2000; Smith et al., 2006), human factors (Wiegmann, et al., 2004), management (e.g., Barling et al., 2002), and engineering (e.g., Varonen and Mattila, 2000). Industries investigated include manufacturing (e.g., Cooper and Phillips, 2004; Griffin and Neal, 2000; Zohar and Luria, 2003), construction (e.g., Dedobbeleer and Beland, 1991; Probst et al., 2006); health care (e.g., Gaba et al., 2003; von Thaden, et al., 2006), offshore drilling (e.g., Mearns et al., 1998), aviation (e.g., McDonald et al., 2000; Gibbons, et al., 2006; von Thaden, et al., 2008), and numerous others.

Despite the increased proliferation of studies in safety culture and safety climate, the research has remained fragmented and it is difficult to draw broad conclusions (Zhang, Wiegmann, von Thaden**,** Sharma & Mitchell, 2002; Wiegmann, Zhang, von Thaden, Mitchell & Sharma, 2002). Part of this difficulty comes from the confusion surrounding the terms safety culture and safety climate. Some researchers argue that safety culture and climate are the same construct (Guldenmund, 2000, 2007; Lee & Harrison, 2000; O'Toole, 2002; Vredenburgh, 2002; Cox & Flin, 1998), and others that safety climate is a sub-concept of safety culture (Lin et al, 2008; Zohar, 2000; Cooper, 2000; Glendon & Stanton, 2000; Neal, Griffin, & Hart, 2000; Silva, Lima, & Baptista, 2004). Wiegmann et al. (2002) reviewed numerous formal definitions of safety culture and climate and found that the former tended to emphasize enduring characteristics of the organization and to be aligned with traditional theories of organizational culture as a social-anthropological construct (e.g., Deal & Kennedy, 1983; Schein, 1991) (discussed in section 2.1.1). Definitions of safety climate, by contrast, placed greater emphasis on the perceptions of employees (as opposed to objectively measurable "true" characteristics) and the fact that these perceptions were subject to change depending on circumstances. The distinction between safety culture and safety climate therefore appears to be loosely analogous to the distinction that has long been made in the personality literature between psychological states verses traits (Spielberger, 1966). In other words, behavior can be influenced by circumstantial factors that elicit psychological reactions (i.e., states), such as anxiety or anger, as well as by enduring personality characteristics (i.e., traits), such as introversion/extroversion. Therefore, repeated observations or interactions may often be required in order to decipher enduring personality characteristics (consistent ways of reacting across situations), independent of temporary states elicited by specific contextual factors (for a thorough discussion of the concept, see Wiegmann et al., 2002).

It appears, however, that this distinction is often lost in practice. In general, contemporary studies of safety culture and safety climate use similar operational definitions of the construct: most use survey techniques to measure employees' perceptions of organizational factors. Safety culture seems to be the preferred term in high-risk industries such as nuclear power or health care, but safety climate is more frequently used in the context of manufacturing, construction, or other industries. Even this distinction, however, is not clear cut, and the measures used by both groups are highly similar. This research draws on both the safety culture and safety climate literatures and views the constructs discussed therein as largely equivalent.

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[1] SSCI Index: 2000-2008: 358 citations for "safety climate," 522 for "safety culture," and 130 for both terms combined (overlap).

Another challenge for safety culture/climate research is the lack of a well-defined research community to facilitate information sharing. While some culture/climate research has been widely disseminated, much of it has been confined to technical reports and small industry-specific journals, offering useful descriptive or diagnostic information for the participating organizations but contributing little to a broad theory. Measures and even definitions of safety culture/climate vary widely from study to study (Wiegmann, Zhang & von Thaden, 2001; von Thaden & Gibbons, 2007). These differences are largely due to the type of industry and the context of the relative safety area studied within these industries (e.g., high risk safety critical industries, factory operations, occupational health factors/trips and falls, etc.).

Increasingly, researchers have sought to address this fragmentation by conducting studies that compare across jobs, organizations and industries (e.g., Barling et al., 2002; Smith et al., 2006). These studies, by necessity, use broad measures of safety climate, and it cannot be assumed that "safety" looks the same for all participants. For example, the sample of workers examined by Smith and colleagues (2006) included employees in the mineral, retail trade, and manufacturing sectors (among others). Essential safety behaviors for mining personnel are likely to be quite different from those expected of retail sales staff. Indeed, Smith and colleagues concluded that differences in the hazard rates of the industries considered in their study explained a much larger proportion of the variance in injury rates than did safety climate. This suggests the possibility that such cross-industry studies may often be comparing apples and oranges. For example, Gaba et al. (2003) found substantial differences between the safety climates reported by a group of hospital employees and a group of naval aviators, but it is difficult to interpret what these differences mean. Gaba and colleagues found only a small common core of safety climate items that were applicable to both industries. The concern then is that the study of safety climate/culture can be seen as an unrestricted ideal; available to be measured and compared without adequate consideration of the differences in operational environments both within an organization and across organizations (Reiman & Oedewald, 2007).

At the same time, several studies have identified commonalities among safety culture and climate measures. Flin, Mearns, O'Connor, and Bryden (1998) found common themes in over 18 safety climate surveys suggesting that the most typically assessed dimensions are related to management, safety system, and risk, followed by work pressure and competence; noting that procedures and rules should also receive attention. Guldenmund (2007) has also identified 9 dimensions related to organizational policy: hardware, maintenance, manpower planning, risks, procedures, competence, commitment, communication, and change monitoring. Similarly, Wiegmann et al. (2002) reviewed safety culture and climate measures and proposed five main themes of organizational commitment, management involvement, employee empowerment, reward systems, and reporting systems. Zohar (2003) noted that *both* general and industry-specific factors may be necessary to describe safety climate completely. In other words, although some elements of a positive safety climate may be applicable to all organizations and industries, different industries may need to include additional components that address more specific issues.

2.1.1 Safety Culture Defined.

The current term safety culture can be traced to the Chernobyl reactor disaster in April 1986. The term was used by the International Atomic Energy Agency noting a "poor safety culture" as a factor contributing to the disaster summarizing management, organizational and regulatory factors as well as attitudes important to safety (IAEA, 1986, as cited in Cox & Flin, 1998; Sorensen, 2002). Within commercial aviation the turning point for the analysis of organizational factors came with the in-flight structural breakup and crash of Continental Express Flight 2574 near Eagle Lake, Texas, on September 11, 1991 (Meshkati, 1997). In a dissenting opinion, John Lauber of The National Transportation Safety Board (NTSB) suggested that the probable cause of this accident included, "The failure of Continental Express management to establish a corporate culture which encouraged and enforced adherence to approved maintenance and quality assurance procedures" (NTSB/AAR-92/04, 1992:54). The commercial aviation industry has displayed a strong interest in organizational safety culture, in part precipitated by the role attributed to a lack of corporate safety culture in the crash of Continental Express Flight 2574, and in part to determine the true contributing root causes in accidents and incidents in an effort to improve safety and prevent loss. Aviation accidents are virtually never the result of a single cause or a single individual operator (Bird, 1974; Heinrich, Petersen, & Roos, 1980; Wiegmann & Shappell, 2003). In fact, accidents are the result of a number of causes, only the last of which are the unsafe acts of the individual on the front line (von Thaden, et. al, 2006; Wiegmann & Shappell, 2003). While identifying a primary accident cause is viewed as necessary in field investigations, this practice may actually prove deceptive and hinder the analysis of the multiple causes leading to the outcome. Many field investigators have referred to the operator's unsafe or erroneous action or decision, with little indication of the contributing factors leading to the accident throughout the organizational chain of command. As a result, supervisory and organizational factors have often been overlooked or unidentified by aviation accident investigators in the field despite growing recognition in the research literature of the role such factors play (Heinrich, et. al, 1980; ICAO, 1993; Yacavone, 1993; Maurino, Reason, Johnston, & Lee, 1995). The challenge for safety professionals and inspectors alike, therefore, is to identify and mitigate organizational factors that affect aviation safety before they result in an accident or incident.

Even when the importance of organizational safety factors is understood and acknowledged, many airlines struggle to balance safety and profitability. Most utilize procedures such as the Aviation Safety Action Program (ASAP), Flight Operational Quality Assurance (FOQA), and other safety audit or in-house systems to track error or unsafe conditions, but few know what to do with the information once it is gathered (Smith, et. al, 1992). Airline safety personnel describe overwhelming amounts of information and lack of time and resources to do much with the large quantities of information accumulated through such program. Their accounts indicate they spend the bulk of their time reacting to problems that emerge from incidents or investigations. While a proactive program is intended to be a high priority, it often gets put off while the safety department manages other problems that take short-term higher priority. Some safety directors lament that they are continually "chasing their tails," or addressing "urgent" problems that yield little real progress. Shifting an organization's mindset from reactive to proactive safety requires not only a set of safety audit tools (such as ASAP or FOQA), but also a full endorsement from upper management to establish a program with adequate resources and personnel committed to focusing on the humans and their work processes in the organizations. In short, while airlines embrace "safety culture" in theory, they appear ill-equipped to put it into practice.

Safety culture is typically defined as a group-level construct with various dimensions pertaining to the occupation studied. Safety culture has previously been defined as the enduring value and prioritization of worker and public safety by each member of each group and in every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety; act to preserve, enhance and communicate safety information; strive to actively learn, adapt and modify (both individual and organizational) behavior based on lessons learned from mistakes; and be held accountable or strive to be honored in association with these values (von Thaden, Kessel & Ruengvisesh, 2008, adapted from Wiegmann, Zhang, von Thaden, Sharma & Mitchell, 2002:8). This definition combines key issues such as personal commitment, responsibility, communication, and learning in ways that are strongly influenced by processes instantiated by upper-level management, but also influence the behavior of everyone in the organization (cf. Wiegmann, et. al, 2004). It should be noted that the definition of safety culture is stated in neutral terms. As such, the definition implies that organizational culture exists on a continuum and that organizations can have either a good or poor safety culture. Safety culture influences behavior across levels within an organization. The overall safety culture of an airline may drive resource management decisions, shape organizational climate, and influence the development of organizational processes. It implies that a safety culture in any organization basically exists, but is expressed in varying quality. Safety culture represents a complex understanding wherein an organization must evaluate its strengths and vulnerabilities to promote the creation of a consistent, positive safety culture. To promote a strong culture of safety, an organization must proactively train the positive characteristics and inform the community of the priority of safety in operations (e.g., the safety climate). Therefore indicators of organizational safety culture must be specifically indentified and clearly measured for any training or procedural changes to be introduced and accepted into the organization. Without identification and measurement of the organization's safety culture, effective implementation of safe practices may be hindered by unidentified barriers.

Methods for studying organizational culture tend to vary according to the academic discipline from which they originate (Helmreich & Merritt, 1998, Wiegmann et al., 2002). In general, the approaches can be grouped into two broad categories: the socio-anthropological and the organizational psychological perspectives (Wiegmann, et al., 2002). The socio-anthropological perspective highlights the underlying structure of symbols, myths, heroes, social drama, and rituals manifested in the shared values, norms, and meanings of groups within an organization (Deal & Kennedy, 1983; Mearns & Flin, 1999). While the organization's culture may be revealed in the workers general patterns of attitudes and actions, the deeper cultural structure is often not immediately interpretable by outsiders. This perspective also generally considers that the culture is an emergent property of the organization (Smircich, 1983) and therefore cannot be completely understood through traditional analytical methods that attempt to breakdown a phenomenon in order to study its individual components, but rather through methods that account for the activity or the nature of what is being studied (Creswell,1998; Glaser & Strauss, 1967; Suchman, 1987). The organizational psychological perspective defines organizational culture as the values and beliefs that organization members come to share through symbolic means such as myths, rituals, stories, legends and specialized language (Smircich, 1983). This perspective assumes that organizational culture can be broken down into smaller components that are empirically more tractable and more easily manipulated (Schein, 1991) and in turn, can be used to build organizational commitment, convey a philosophy of management, legitimize activity and motivate personnel. In short, it may be as simple as a qualitative versus quantitative argument, for which one methodology cannot completely suffice, but rather a fusing of techniques.

The key in any safety culture improvement program is to develop effective measures to evaluate the current state of a particular safety culture, as well as to determine whether interventions have been effective in achieving a desired cultural change. Both quantitative and qualitative techniques can contribute to this goal. Survey methodology is cost-effective for large organizations as data can be collected and analyzed rather quickly. Surveys also offer the advantage of allowing a large percentage of an organization's population to respond and to do so anonymously. The SCISMS was developed to assist in diagnosing strengths and vulnerabilities within the safety culture of an organization so that the limitations can be addressed and strengths exploited. It allows organizations to be studied over time and compared across operations. SCISMS itself is flexible in its approach: the survey items can be varied to capture the specific conditions of each operational unit, but the overall framework remains constant. This means that individual departments or units can receive detailed, specific feedback (rather than feedback based on a set of broad, one-size-fits all items), but the overall results are presented in a common language to facilitate comparisons. For example, the specific items in the Authority scale might be worded differently for pilots than for maintenance technicians, since the safety-related responsibilities of each group are different, but it is not unreasonable for an airline to compare the degree of Authority given to its pilots with that given to its technicians.

3. EVALUATION APPROACH.

SCISMS was developed to address the need for an integrative framework that includes both organizational level formal safety management systems, and individual level safety-related behavior. Surveys and questionnaires have been widely used to assess safety culture in variety of complex and high risk industries but until 2001, few comprehensive measures of safety culture had been developed for the commercial aviation industry. A comprehensive safety culture survey is the first step for airlines to take a proactive approach to safety culture. By measuring their current indicators of safety culture, organizations obtain an overview of the effectiveness their safety management system. This measurement is not an exercise in rooting out failures; rather it is performed to gain a more thorough understanding of normal operations. Through gaining this understanding of how work is actually performed, we can see what may be going right and what may be going wrong in an organization. By understanding what is going right or working well in an organization, we are able to inform the company about processes they may wish to amplify. We can also inform the company of any identified problem areas they then may wish to target with more in-depth, qualitative investigations, addressing the most pressing problems as a priority. Airlines should routinely survey their employees to evaluate the efficacy of implemented safety programs, and to aid decision making in times of significant organizational change. For example, with the growth in airline mergers, the airlines undergoing a merger greatly benefit from understanding the safety culture of both organizations prior to merge, and then throughout the process. This allows management to make informed decisions about future policies or anticipate potential incompatibilities between the organizations. Conversely, airlines entering into more aggressive outsourcing arrangements may wish to understand the challenges associated with the interface between the outsourced processes and in-house culture.

4. THE SAFETY CULTURE INDICATOR SCALE MEASUREMENT SYSTEM

Researchers at The University of Illinois at Urbana-Champaign (UIUC) developed a measure associated with safety culture in high reliability organizations. Beginning circa 2001 with the Commercial Aviation Safety Survey (CASS), the instrument has been refined to its current state of the Safety Culture Indicator Scale Measurement System (SCISMS) and has been distributed globally in the aviation industry. SCISMS construct represents a four-factor model reflecting Organizational Commitment, Formal Safety Indicators, Operations Interactions, and Informal Safety Indicators which are correlated with the personal safety attributes/behaviors of the individual (see figure 1) (Gibbons, von Thaden & Wiegmann, 2004; Gibbons, von Thaden & Wiegmann, 2006; von Thaden, Gibbons & Li, 2007, von Thaden, 2008). The SCISMS has been designed to identify the strengths and areas in need of improvement concerning the safety culture in an organization.

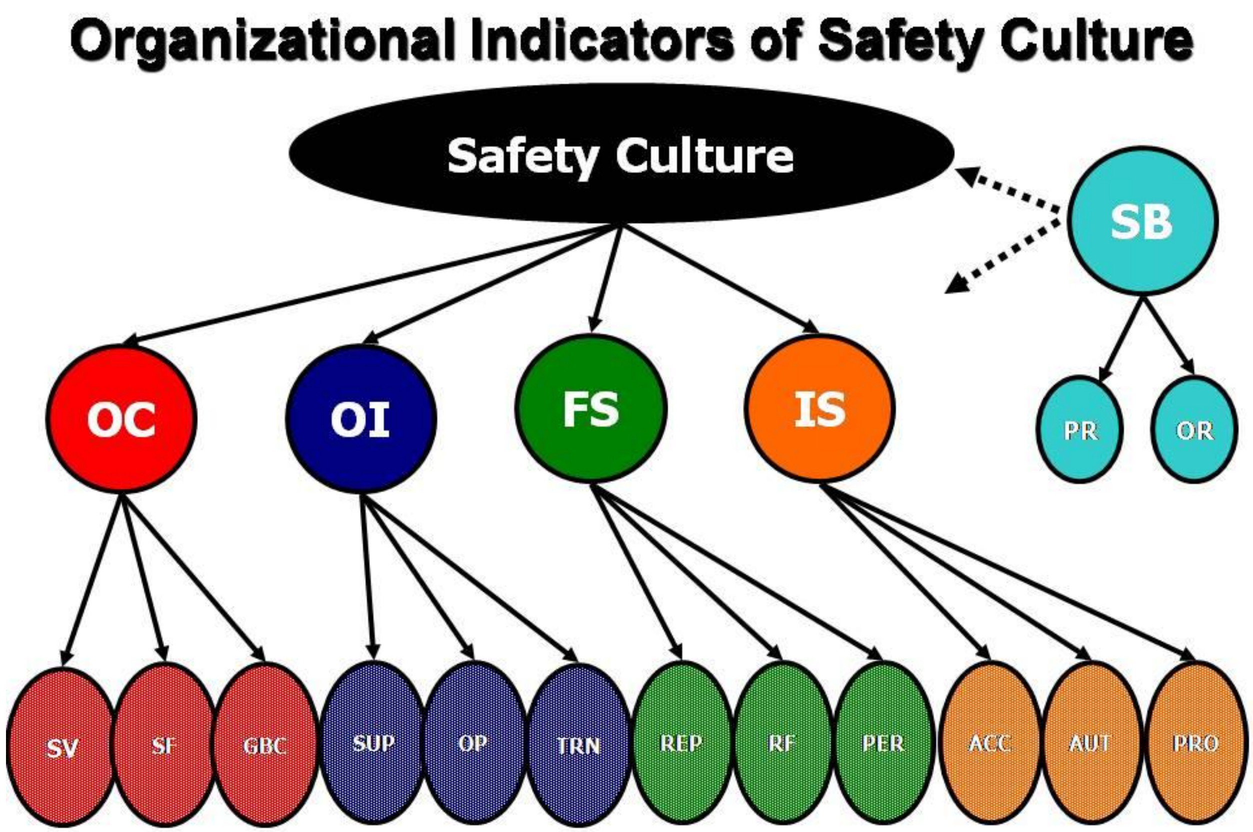

Figure 1. The Safety Culture Indicator Scale Measurement System (SCISMS) model.

The survey uses a 7-point Likert-type response scale to indicate respondent agreement or disagreement for each item and provides space at the end of each section for respondents to write comments. This allows for both a quantitative measure of the organization's safety culture, and qualitative evidence to understand the specific areas that work well or need improvement. The quantitative portion of the survey gives information to gauge the extent of the organization's commitment to safety culture and allows for statistical measures of concepts that heretofore have been speculative. However, numbers alone do not tell a full story. Consider a neutral measure; without qualitative information to understand the basis behind variance in responses; is there broad variation in the responses leading to a neutral result, or is there low variability in the responses and a large portion of the respondents feel uncertain? Numerical data alone may not provide adequate information of the true concerns affecting an organization and its employees.

The flight and maintenance operations versions of the SCISMS have been tested and validated over a series of organizations. SCISMS has proven itself a useful diagnostic tool built to illustrate industry practice through its use as a longitudinal benchmarking tool, and it also serves to individually identify and analyze specific strengths and areas in need of improvement in an aviation organization, providing useful information to airline management seeking to improve safety culture. Indeed, when briefed, the airlines surveyed using SCISMS were appreciative of the information revealed and many took corrective action based on the results.

4.1 Key Dimensions of Safety Culture in SCISMS

Organizations demonstrating positive cultural alignment generally are more resistant to unsafe conditions and the hazards that may result when a system is breached. A positive safety culture does not guarantee an accident free workplace, but rather illustrates an organization committed to proactive and collaborative solutions in the continual battle against system error. Key indicators of safety culture include Organizational Commitment to Safety, Operations Interactions, Formal Safety Indicators, and Informal Safety Indicators. There is no single element of importance, but rather an integrated relationship between the cultural aspects of safety at an organization that demonstrates the strengths in its alignment and continually seeks ways to address discrepancies and close safety gaps.

Figure 2. Organizational Commitment as reflected in Safety Values, Safety Commitment, and Going Beyond Compliance.

Organizational Commitment (OC) to safety refers to the degree to which an organization's leadership prioritizes safety in decision-making, and allocates adequate resources to safety management, even if it means system delays to mitigate a problem. In particular, an organization's commitment to safety is reflected in three subfactors, including:

- Safety Values (SV) – Attitudes and values expressed in words and actions by leadership, regarding safety. This reflects the commitment to safety at the top levels of the organization. Safety performance should be actively managed and monitored with the same systematic oversight effort and attention given to exceeding goals, as are company finances.

- Safety Fundamentals (SF) – Compliance with regulated aspects of safety such as training requirements, manuals and procedures, equipment maintenance, and the coordination of activity within and between teams/units. At this level, the organization should encourage safe practices as a way of doing business and provide a solid framework for the organization, its managers and line employees, to meet those safety requirements.

- Going Beyond Compliance (GBC) – Priority given to safety in the allocation of company resources (e.g., equipment, personnel time) even though they are not required by regulations. This may be reflected in areas such as employee rostering, scheduling of shiftwork and rest time, providing advanced technology when essential, fatigue management programs, and other scientifically based risk management systems (figure 2.)

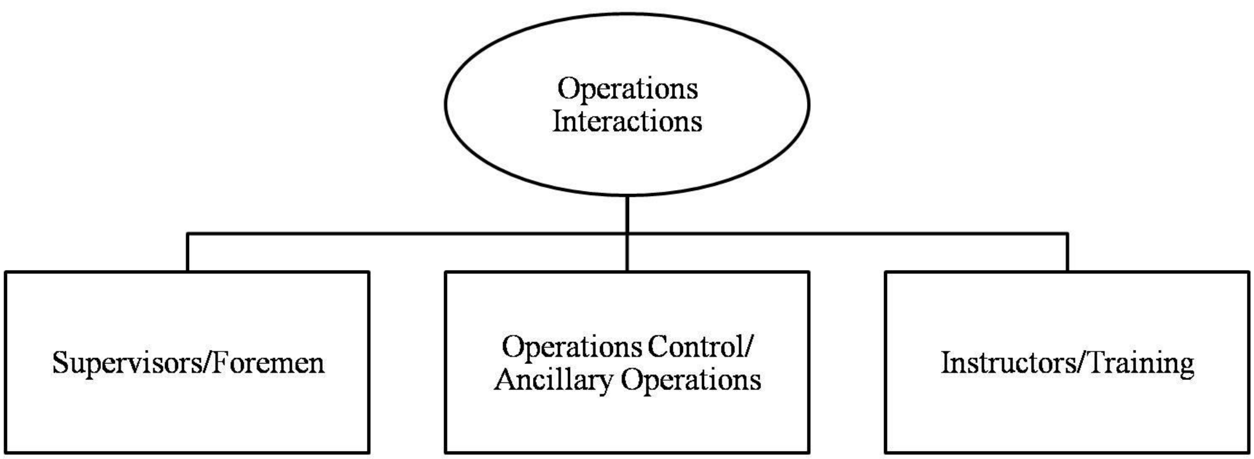

Figure 3. Operations Interactions as reflected in Supervisors/Foremen, Operations Control/Ancillary Operations, and Instructors/Training.

Operations Interactions (OI) is reflected in working relationships with middle management, supervisors, and other operations personnel that take into account involvement in and concern for safety on their part. This entails the priority given to safety by operations personnel and their regard for the actual risks. OI refers to the degree to which those directly involved in supporting work or the supervision of employees are actually committed to safety and reinforce the safety values espoused by upper management, when these values are positive. These include:

- Chief Pilots/Supervisors/Foremen (SUP) - Their involvement in and concern for safety on the part of supervisory and "middle" management at an organization. Particularly their proactive concern for employee and system safety, and their ability to convey a safe environment.

- Instructors/Training (TRN) – The extent to which those who provide safety training are in touch with the actual risks and issues associated with performing a particular job and the extent to which training is offered and is deemed effective. Is safety training integrated across all operational personnel? Are best industry practices trained?

- Other groups of operations personnel fall under the general heading of Operations Control/Ancillary Operations (OPC). This includes interactions and work integration among those who are responsible for ensuring that priority is given to safety in conducting supportive roles. For example, the flight operations survey may focus on Dispatch, Maintenance, Ground Handling Personnel, and Flight Attendants. This includes effectively managing, maintaining, and inspecting the safety integrity of the equipment, tools, procedures, etc. or serve ancillary operational functions (e.g. Dispatch, Maintenance Control, Ground Operations, etc.), and conveying information such as through conducting safety briefings (figure 3).

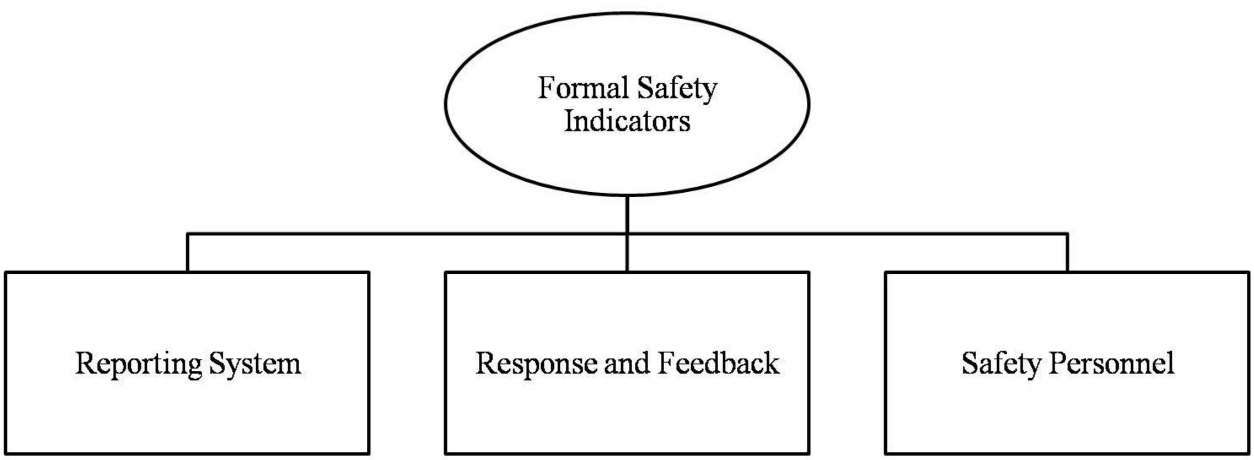

Figure 4. Formal Safety Indicators as reflected in Reporting System, Response and Feedback, and Safety Personnel.

Formal Safety Indicators (FS) refers to organizationally instantiated procedures and systems for reporting and addressing both occupational and process safety hazards. Such formal systems include:

- Reporting System (REP) – It is not enough for an organization to have a system to collect safety related event data; it must be a non-punitive system if it is to encourage incident and hazard reporting. Concerns center on the accessibility, familiarity, and actual use of the organization's safety reporting system. Is the system used as per its intent, do employees feel safe using it, and do they, in fact, use it?

- Feedback and Response (RF) –Timeliness and appropriateness of management responses to reported safety information and dissemination of safety information to workers. Once data is captured, is should be it analyzed and shared on a routine basis so that safety lessons may be learned throughout the organization.

- Safety Personnel (PER) – Perceived effectiveness of and respect for persons in formal safety roles (e.g., Safety Officer, Vice President of Safety). Are they competent or seen as "paper tigers?" Do they actively exchange information to promote best safety practices? Do safety personnel systematically track data trends in an effort to reduce or eliminate emerging problem areas (figure 4)?

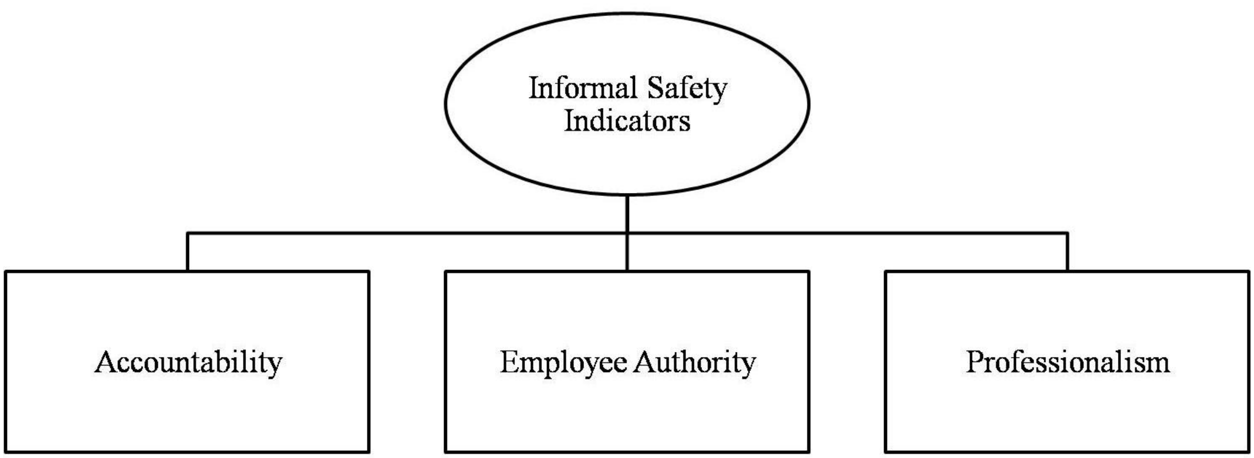

Figure 5. Informal Safety Indicators as reflected in Accountability, Employee Authority, and Professionalism.

In contrast to formal safety indicators, Informal Safety Indicators (IS) refer to the unwritten rules pertaining to safety behavior, including rewards and punishments for safety and unsafe actions and the manner in which such rewards and punishments are instituted in a justly and fairly. Specifically, informal safety indicators include such factors as:

- Accountability (ACC) – The consistency and appropriateness with which employees are held accountable, or blamed, for unsafe behavior. Is there a competent investigation of events that identifies systemic safety deficiencies? Concerns center on justice and favoritism.

- Authority (AUT) – Authorization and employee involvement in safety decision making. As employees represent the eyes and the ears of the organization, they are well suited to propose safety solutions and investigate reengineering ineffective or dangerous work processes.

- Employee Professionalism (PRO) – Peer culture employee group norms pertaining to safe and unsafe behavior. Are Standard Operating Procedures (SOPs) effectively implemented? Are employees committed to checklist usage (figure 5)?

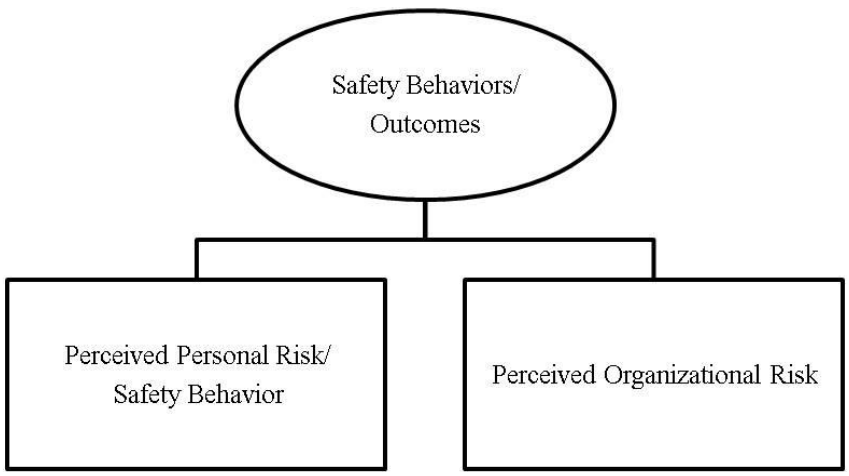

Figure 6. Safety Outcomes as reflected in Perceived Personal Risk and Perceived Organizational Risk.

Safety Outcomes. An airline's safety culture is expected to predict both safety behaviors among employees and employees' perceptions of risk (e.g., Cooper & Phillips, 2004; Rundmo, 2000). Knowing which safety factors are most strongly related to safety outcomes indicates the relative importance of each factor in how the culture is shaped and suggests directions in which to focus improvement efforts. There are many different ways in which safety outcomes might be assessed. Lee and Harrison (2000) identified employees' negative attitudes as significantly associated with the likelihood of an accident. Neal and Griffin (2006) verified the latent effects of this same concept between safety climate and accident rates demonstrating that group safety climate shapes individual safety motivation, which in turn influences individual safety behavior, and thus accident rates.

The SCISMS contains two outcome scales: Perceived Personal Risk/Safety Behavior and Perceived Organizational Risk (figure 6). It is important to note that these measures reflect employees' perceptions of the state of safety within the airline, and as such reflect the safety climate. They should not be interpreted as absolute or objective measures of safety behavior or risk. However, perception measures do reflect the experiences and expectations of employees on the line who have the most opportunity to observe their own and others' behavior.

The Perceived Personal Risk scale seeks to address an employee's perceptions of the prevalence of safety-relevant behaviors. These behaviors are intended to represent deviations from safety standards and the attitudes employees have towards such deviations. These items address the attitude for the priority of safety displayed in circumstances where speed and proficiency are necessary components of the work. Major, intentional risk-taking behavior is infrequent, and survey respondents are unlikely to report such behaviors. Some more minor behaviors included in the Safety Behavior scale reflect more common, and perhaps more accepted, risks, which nonetheless breach system safety, and have resulted in undesired outcomes. Understanding the patterns of safety behavior allows a measure of safety climate and thus the importance of personal action can be correlated with the overall safety culture of an organization.

Items in the Perceived Organizational Risk scale address an employee's beliefs about the likelihood of negative safety occurrences at the airline as a whole. They constitute a global evaluation of an employee's assessments of the airline's overall safety level. This measure allows the assessment of what factors the employees perceive as out of their control and in the hands of "the airline" itself; i.e., the demonstrated leadership safety climate.

4.2 Evaluation Method.

There has been a great interest in safety culture over the years which have led to many different definitions and measures of this construct in a variety of complex, high risk industries. SCISMS was developed to provide a diagnostic tool to assess the current state of the perceived safety climate within a given airline safety culture. The survey was originally developed circa 2001 as the CASS. The survey methodology was constructed under a grant from the FAA by a team of developers with backgrounds in: Aviation Operations (Flight and Maintenance), Human Factors, Business Commerce, Information Science, Systems Engineering, and Organizational/Industrial and Cognitive Psychology. Although the FAA funded this work, no identifying airline data has ever been shared with the FAA.

The survey developed through research into background theory and assessment of organizational accidents. A database of over 1,000 questionnaire items was created from previously developed instruments on safety culture and climate (nuclear power, manufacturing, military aviation, petroleum and construction). During the original design phase the survey prototype was beta tested at volunteer airlines to verify the appropriateness and validity of the items.

The survey was then evaluated and validated over a series of years and voluntary organizations to fine tune the instrument as reflected in their goals and objectives for a safety culture. Since then, organizational assessment has been performed to determine the areas of interaction in Part 121 aviation operations; both areas of alignment and gaps. This phase of study resulted in the SCISMS. Each SCISMS is approximately 113 questions, taking approximately 30 minutes to complete, depending upon the amount of commentary information the respondent is compelled to write.

The SCISMS instruments have been thoroughly vetted. Aviation organizations to date who have officially engaged in the SCISMS consist of:

- Commercial Aviation Operations (e.g., FAR Part 121 & Part 135)
- FAR Part 91 & Part 91K Aviation Operations
- Air Tour Operations (FAR Part 135)
- EMS Operations (FAR Part 135/Part 91)
- Domestic, International and Foreign (to the US) Major Air Carriers
- Passenger and Cargo Operations
- Air Carrier Owned (US and non-US) Maintenance Facilities
- MRO Facilities (FAR Part 145)

Survey instruments have been developed to test a single operation, or the interaction between these operational departments:

- Flight Operations
- Maintenance Operations
- Ground Operations
- Cabin Operations
- Dispatch Operations

The validation process has involved several iterations of the survey and incorporated psychometric evidence, conceptual considerations, and respondents' comments at each stage to determine improvements. In this section, we present a brief summary of the development of the survey; full details of each step can be found in the technical reports referenced below.

4.2.1 Flight Operations Survey Development and Revision

The flight operations version of the survey was developed first, based on the five-factor model proposed by Wiegmann et al. (2002). In an initial test (Wiegmann et al., 2003), the five subscales showed acceptable or better reliability (α = .70 and higher), though item-level analyses identified several poor items and respondent comments suggested ways to improve the wording of several items. Unfortunately, a small sample size (n = 43) precluded a more complex analysis of the degree to which the items fit the hypothesized five-factor model. A subsequent study (Gibbons et al., 2004) with a larger sample (n = 503) used confirmatory factor analyses and found that the five-factor model fit the data poorly. Three of the original five factors (accountability system, management involvement, and reporting system) showed good structure after removing a few problematic items. Analysis of the other two factors (organizational commitment and employee empowerment) suggested that each of these factors in fact consisted of multiple subdimensions. Exploratory factor analysis indicated that the organizational commitment scale was best fit by a three-subfactor model, making distinctions between items describing upper management's perceived attitude toward safety (now Safety Values), compliance with mandated aspects of safety (now Safety Fundamentals), and willingness to expend resources to improve safety above and beyond regulatory requirements (now Going Beyond Compliance). Similarly, exploratory factor analysis of the Employee Empowerment scale also suggested three subfactors: pilots' opportunity for input into safety-related decisions ("Pilot Input"), pilots' willingness to hold their peers accountable for safe behavior ("Peer Influence"), and pilots' personal commitment to safety ("Pilot Responsibility/Commitment"). The revised model, now containing nine factors, yielded much better fit indices, though these still fell below the criteria for "acceptable" fit.

The psychometric analysis above was then reconsidered from a conceptual viewpoint. Many of the items in the new subscales of Employee Empowerment seemed to overlap with the intent of the items in the Accountability System scale. Accordingly, these were integrated into a new broad factor – Informal Safety System – with subfactors of Accountability, Authority, and Professionalism as described above. The three subfactors of the Organizational Commitment scale were retained. Upon reading respondents' comments, it seemed appropriate to separate the Reporting System scale into two subscales, one emphasizing the reporting system itself (Reporting System) and one emphasizing the airlines' response to that information (Response & Feedback), as respondents indicated these were often quite distinct in practice. A third scale (Safety Personnel) was added to this group to capture the role of those individuals with formal authority over safety. These three subscales (Reporting System, Response & Feedback, and Safety Personnel) were combined under the general factor Formal Safety System. The Management Involvement scale underwent perhaps the greatest change as the result of the conceptual analysis. Although the confirmatory factor analysis suggested that these items described a relatively unitary construct, respondents' comments suggested that the term "management" was too broad and that their answers would depend on which types of management personnel were meant – chief pilots, dispatch, upper management, etc. Further, the Management Involvement factor was highly correlated with most of the Organizational Commitment subscales, suggesting that many respondents may have been thinking of upper management when they saw the term "management," rather than chief pilots and others in supervisory but not executive positions.

This led to a shift in our thinking with significant implications for the design of the current SCISMS. As noted earlier, most studies of safety culture within a single organization focus on a single job function, where everyone shares similar responsibility for safety. In aviation, there are multiple groups of personnel who play different, but integrated, roles in achieving safety. Safe flight operations depend not only on the safe behavior of the individuals within each job function, but also on the coordination and communication between diverse groups. This integration, or the lack thereof, is an essential component of an airline's safety culture. Focusing solely on traditional hierarchical levels (employee, supervisor, upper management) may be appropriate for, say, a manufacturing organization, but cannot fully capture the safety culture of an airline. As a result, separate scales for each relevant personnel group were created and grouped together in the Operations Interactions factor. The items in the Management Involvement scale were rewritten to focus specifically on chief pilots, and corresponding scales were developed for dispatchers and instructors/training, as these were identified as important in respondent comments. Table 1 contains the inventory for the Part 121 flight operations SCISMS.

Table 1. Scale inventory for the Part 121 flight operations version of the SCISMS.

SCISMS Major Factor Scale	Sub Factor Scales
Organizational Commitment	
	Safety Values
	Safety Fundamentals
	Going Beyond Compliance
Operations Interactions	
	Chief/Fleet Pilots
	Instructors/Training
	Dispatch
	Operations Control
	Ground Handling/Ramp Operations
	Maintenance/Engineering
	Cabin Crew
Formal Safety Indicators	
	Reporting System
	Response & Feedback
	Safety Personnel
Informal Safety Indicators	
	Accountability
	Pilots' Authority
	Professionalism

4.2.2 Maintenance Operations Survey Development and Revision

A version of the survey was also developed for Part 121 maintenance operations, based on the design and items of the original survey, and a similar validation process was conducted (Gibbons et al., 2005). Again, the hypothesized five-factor model of Wiegmann et al. (2002) did not fit the data well, and the results of the individual scale analyses were quite similar to those of the flight operations survey. Exploratory analyses again suggested dividing the Organizational Commitment and Employee Empowerment scales into three factors each, and these subfactors corresponded loosely (though not exactly) to those identified in the flight operations analysis. Accordingly, a revised model for maintenance was proposed, including the four major factors described above, with slight variation in the subfactors associated with each. The specific groups of personnel included in the Operations Interactions factor varied from the flight operations version. Table 2 contains the inventory for the Part 121 maintenance operations SCISMS.

Table 2. Scale inventory for the Part 121 maintenance operations version of the SCISMS.

SCISMS Major Factor Scale	Sub Factor Scales
Organizational Commitment	
	Safety Values
	Safety Fundamentals
	Going Beyond Compliance
Operations Interactions	
	Supervisors/Leads
	Instructors/Training
	Maintenance Control
	Flight Crew
	Cabin Crew
	Dispatch
Formal Safety Indicators	
	Reporting System
	Response & Feedback
	Safety Personnel
Informal Safety Indicators	
	Accountability
	Technicians' Authority
	Professionalism

Test reliability refers to the consistency or replicability of a set of test or questionnaire items. A reliable scale is one that will yield the same score for two different individuals with the same true level of the trait or attitude being measured, or for one individual tested twice (assuming that no changes have occurred between tests). Within a scale, items that assess the same underlying dimension are related or correlated with one another. A common measure of reliability is the Guttman-Cronbach alpha coefficient (Cronbach, 1951; McDonald, 1999), which is based on the correlations between the items in a scale and the length of the scale. Alpha coefficients derived from the data can range from zero to one, but standards regarding its size depend on a number of factors, including the nature of the research and the degree to which scale items are redundant (Nunnally, 1967; John & Benet-Martinez, 2000). Usually, alpha coefficients at or above .70 are considered acceptable, particularly when scales are short. Subsequent SCISMS survey tests and validation efforts have produced gratifying reliability (α = .81 - .95). Table 3 illustrates example Alpha scores as calculated from a recent SCISMS survey conducted in a major airline's flight operations department (n= ~3700), revealing highly reliable instrument.

Table 3. Example Scale Reliability at a major passenger airline using SCISMS.

Scale	# of items	Alpha
Organizational Commitment	20	**0.91**
Operations Personnel	60	**0.95**
Formal Safety System	17	**0.83**
Informal Safety System	16	**0.82**
Total Reliability	113	**0.97**

4.3 Procedures.

When an organization wishes to perform a safety culture survey, an accountable executive is obliged to champion the survey to the employees of the organization as a chance to gain valuable information regarding the organization's culture of safety in normal operations. During this adoption phase, the program should be scheduled and formally announced.

As part of SMS implementation, SMS training may already have been provided. It is suggested to obtain a baseline measure the organization's culture prior to implementing SMS to understand and measure the effects of the program on the organization.

As part of adopting a safety culture, it is best to notify employees of the impending survey. This is done through newsletters, briefings and postings. It is beneficial to prepare a cover letter from the Safety Officer or Accountable Executive of the organization outlining the purpose of the survey, its voluntary and confidential nature, its importance to the organization and the organization's ongoing commitment to safety. This cover letter should be distributed directly through the organization before the survey instrument is distributed.

At the very least, one to two months before the survey is to be distributed it is advisable to share this information throughout the organization. It is also beneficial to discuss the survey with the various stakeholders (e.g., union representatives) to assure the parties that the SCISMS asks about normal operations and not labor relations. The following information should be shared:

- The survey is completely anonymous and voluntary.
- All surveys go directly to a secure third party, The University of Illinois, who has met strict Institutional Research Board protocols regarding the protection of human subjects.
- The data is protected and will only be reported to the organization in the aggregate.
- No individual identifying data will be presented.
- Respondent comments will be shared with the organization and edited when it appears the writer may be identified.
- To be thorough, both management/leadership and line employees will participate in the survey.

The survey is housed on secure computer server at the University of Illinois. Employees are provided the discrete web address and log in information needed to access the survey. Randomly generated passwords are normally used, which may be distributed to employees' mailboxes or through email. Once directed to the survey link, employees will enter their username and password information to access the survey. Once the survey process has begun, the return process can take two weeks to one month. Return rates are tabulated at the end of each week. If the return rate is lethargic, the company will be prompted send out a gentle reminder letter to gain more input. The process should be closed at the end of one month, at the latest.

Once the final report has been submitted to the organization, feedback is necessary to allow results and recommendations to influence the safety culture program. The organization should evaluate the recommendations and prioritize response throughout the organization. It is necessary to maintain ongoing program measurement to identify valid and reliable processes to assure safety culture effectiveness. This measurement, evaluation, action cycle lends to the continuous safety improvement at the organization and presents safety as front and center in organizational concerns and the safety management system.

5. EXAMPLE DATA.

The structure of the SCISMS permits analysis and reporting of an airline's safety culture at multiple levels. The four major factors allow an at-a-glance, global view of the organization's major strengths and areas in need of improvement (figure 7):

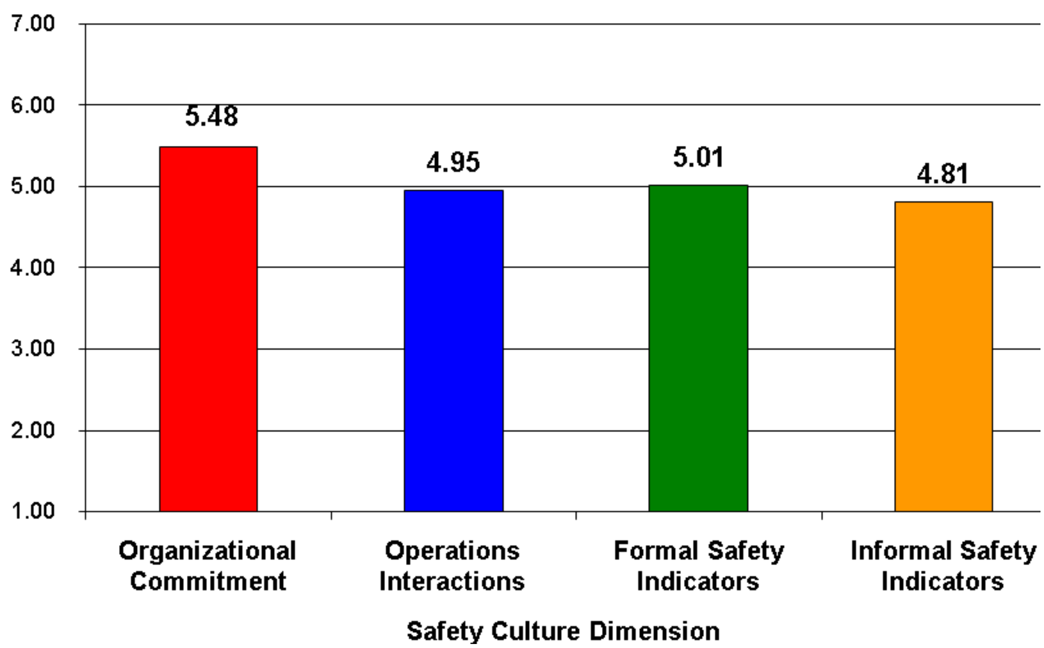

Figure 7. Example mean response over all respondent's for Part 121 airline flight operations SCISMS.

This airline's overall summary suggests that all areas of safety culture are positive (i.e., above the neutral point of 4.0 on a 7-point Likert scale), but Organizational Commitment is the strongest area and Informal Safety Indicators, score lowest.

The subfactors allow a more detailed analysis, particularly for problem areas. For the airline above, the Informal Safety System can be broken down into its component subfactors as follows (figures 8, 9 &10). Histograms represent the distribution of participants' responses to the overall scale:

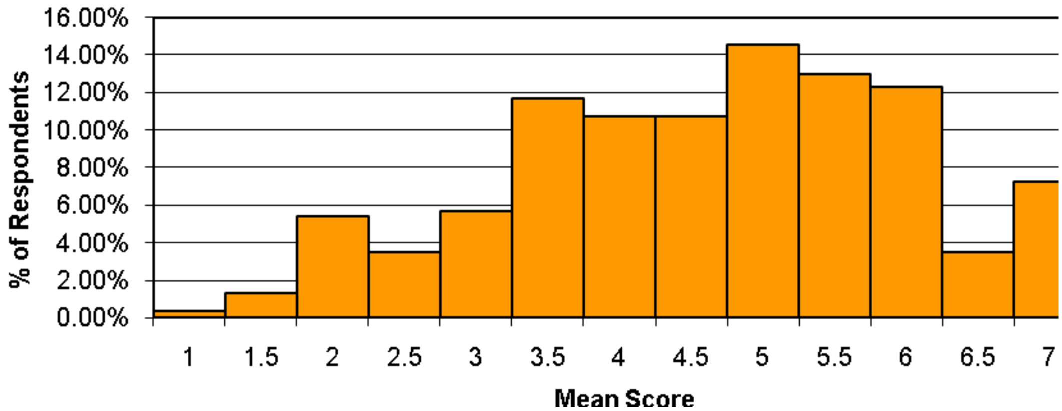

Figure 8. Example distribution of responses to Accountability System subscale (overall mean: 4.50) – Part 121 airline flight operations SCISMS.

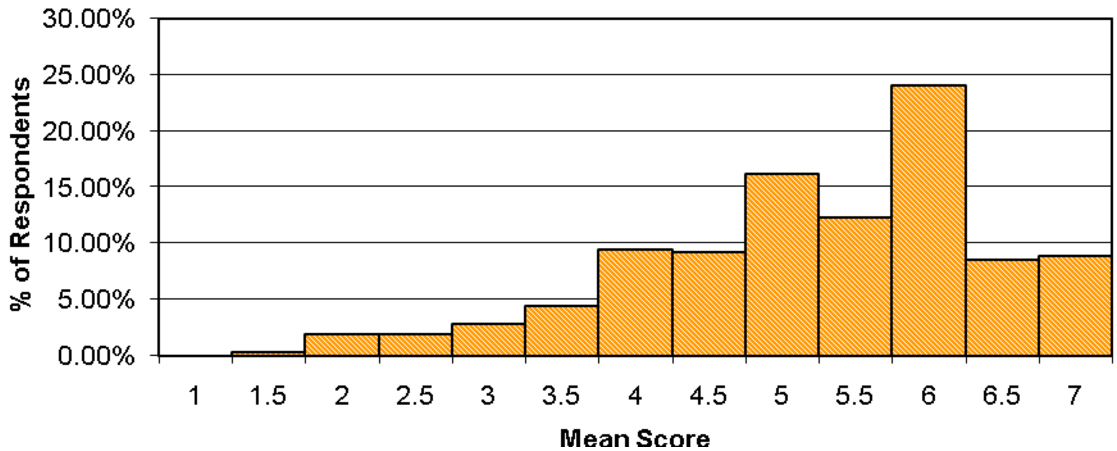

Figure 9. Example distribution of responses to Authority subscale (overall mean: 5.03) – Part 121 airline flight operations SCISMS.

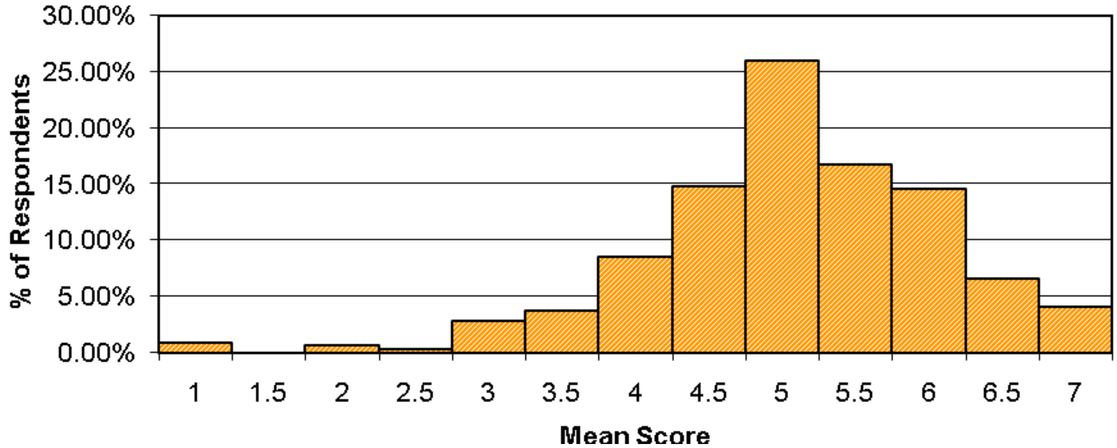

Figure 10. Example distribution of responses to Professionalism subscale (overall mean: 4.91) – Part 121 airline flight operations SCISMS.

The low overall score for Informal Safety Indicators appears to be largely driven by the Accountability scale, which received many negative responses and has the lowest overall mean of the scales in this factor (figure 8). Although there is variability in how pilots perceive their own Authority (figure 9), the overall trend is positive, and there appears to be general consensus that Professionalism is moderately but not highly positive (figure 10). Even further information can be gained by drilling down to the level of individual items. For example, in the problematic Accountability scale (figure 11):

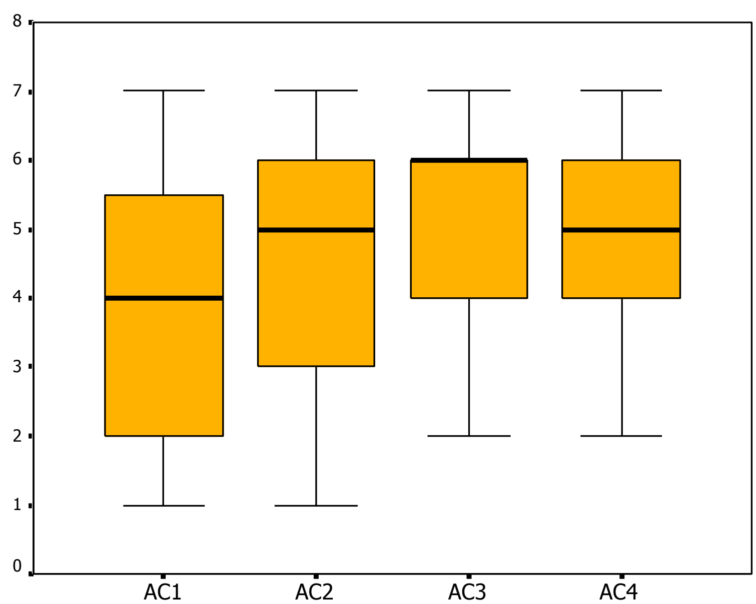

Figure 11. Distribution of responses to Accountability Scale Items using SCISMS.

A boxplot (also known as a box-and-whisker diagram) is a convenient way of graphically depicting summary information, which consists of the smallest observation, lower quartile (Q1), median, upper quartile (Q3), and largest observation; in addition, the boxplot indicates which observations, if any, are considered unusual, or outliers. Boxplots are able to visually show different types of populations, without any assumptions about the statistical distribution. The spacing between the different parts of the box helps to indicate variance and skew and to identify outliers. The box itself contains the middle 50% of the data. The upper edge (hinge) of the box indicates the 75th percentile of the data set, and the lower hinge of the box indicates the 25th percentile. The line in the box indicates the median value of the data. If the median line within the box is not equidistant from the hinges, then the data is skewed. The ends of the vertical lines or "whiskers" indicate the minimum and maximum data values, unless outliers are present in which case the whiskers extend to a maximum of 1.5 times the inter-quartile range. The points outside the ends of the whiskers are outliers or suspected outliers.

The plot in figure 11 indicates that the first item, "This airline's leadership shows favoritism to certain pilots," received the bulk of the negative responses, with a mean of 3.66 (after appropriate reverse coding). Some participants also responded negatively to the second item, "Standards of accountability are consistently applied to pilots in this airline." Responses to the other two items in the scale, regarding the fairness of blame and punishment for pilots' mistakes, were more generally positive. This suggests that the primary challenge regarding Accountability at this airline concerns perceptions of favoritism. It appears that pilots are not blamed unfairly for their errors, but favored pilots may receive more beneficial outcomes than non-favored pilots. This conclusion can be further supported by examining respondents' comments on the Accountability scale as a whole, many of which explicitly deal with the issue of favoritism.

All of the major factors and subfactors of the SCISMS are related to the two outcome scales (Safety Behavior and Perceived Risk). Correlations with Safety Behavior range from r = .32 - .60 (all statistically significant, $p < .05$). At one airline for example, Going Beyond Compliance and Safety Values showed the strongest correlations, and the overall Organizational Commitment factor showed a correlation of .61 with Safety Behavior. This is consistent with arguments by Zohar (2003) regarding the central role of management in promoting a positive safety climate (culture). Correlations between the subscales and Perceived Risk are generally even stronger, ranging from r = -.38 to -.71 (negative correlations indicate that the higher the respondent's perception of safety culture, the lower his or her perceived risk). Again, at the same airline, Safety Values and Going Beyond Compliance were most strongly correlated with Perceived Risk, and the correlation between Perceived Risk and the overall Organizational Commitment factor was -.74.

5.1. Alignments and gaps in safety culture perception

One measure of consistency in the safety culture of an organization is to focus on the variance in survey responses. When a population demonstrates considerable variance, the coherent structure for an underlying culture of safety is for all intents and purposes, nonexistent. Granted, different sub units have different work goals, but the object of airworthiness safety in aviation operations necessarily is the overarching presupposition. While standard operating procedures abound, they do not cover every probable situation likely to be faced by employees at different levels of an organization. Thus policy may be imposed in based in a local procedure or an individual employee's experience. If there is little to no difference in the organizational policy and the local procedure, there is an alignment on the practice. However, if there is a considerable difference between instantiated procedure and the local perception, there is misalignment, or a gap in the safety culture. However slight this misalignment may appear, it can result in significant breaches toward the ultimate goal of system safety. While there may be multiple ways to perform in an open system, if these ways are not agreed upon and shared among the performers, they will not be able to converge toward the common goal of a safety-centered system.

Areas of adequacy for one organizational unit may actually reflect areas of inadequacy for another. When these are combined, the result is instability in the culture of safety. Measuring the variation within an organization can reveal distinct perceptions of the culture and localized safety climate practices. This is important to specifically interpret well or poor performing areas of instituted practice. Areas to consider exploration of variability include: base of operations, job, job tenure, company tenure, age, prior training, and fleet assignment.

Figure 12 (upper left corner) illustrates well-aligned indications of safety culture between the maintenance and flight operations departments in a major air carrier operation. On the other hand, significant differences are visible between the line employees and leadership at another major air carrier (lower right corner, figure 12). These gaps represent problems areas between leadership and line operators in the organization's commitment to safety, its formal safety programs, and the interactions between the operational units at the airline. By studying the individual items and their related comments, specific safety issues and targeted, prioritized solutions can be developed to positively affect a change in the culture. Indeed, the air carrier depicted in figure 12 suffered from the competing goals of speed vs. safety, high employee turnover in specific critical units, and thus an inability to effectively deal with non-routine situations, which have become all too common in today's aviation atmosphere. Specifically, this air carrier operated in areas where it was an actual impossibility to meet, much less maintain, operational schedules. The schedules had not been re-examined extensively for some time, and resulted in ineffective practice. Through no fault of the employees, the system would continually fall behind schedule. Employees were faced with increased work pace at the risk of compromised safety, or a deliberate work pace at the risk of leadership's ire. Thus this tradeoff was reflected in the lower indication of safety culture among the line operators, and in high turnover, and lack of experience on the job to perform flexibly. Leadership, it appears, had a more positive view of the safety culture as they felt employees were performing optimally under the current strained aviation system. Armed with information from the SCISMS survey results, and with additional input from the employees, leadership invested in group level training, and stripped extraneous routines from the system processes. In fact, they have since had higher employee retention, and improved interactions among the working groups.

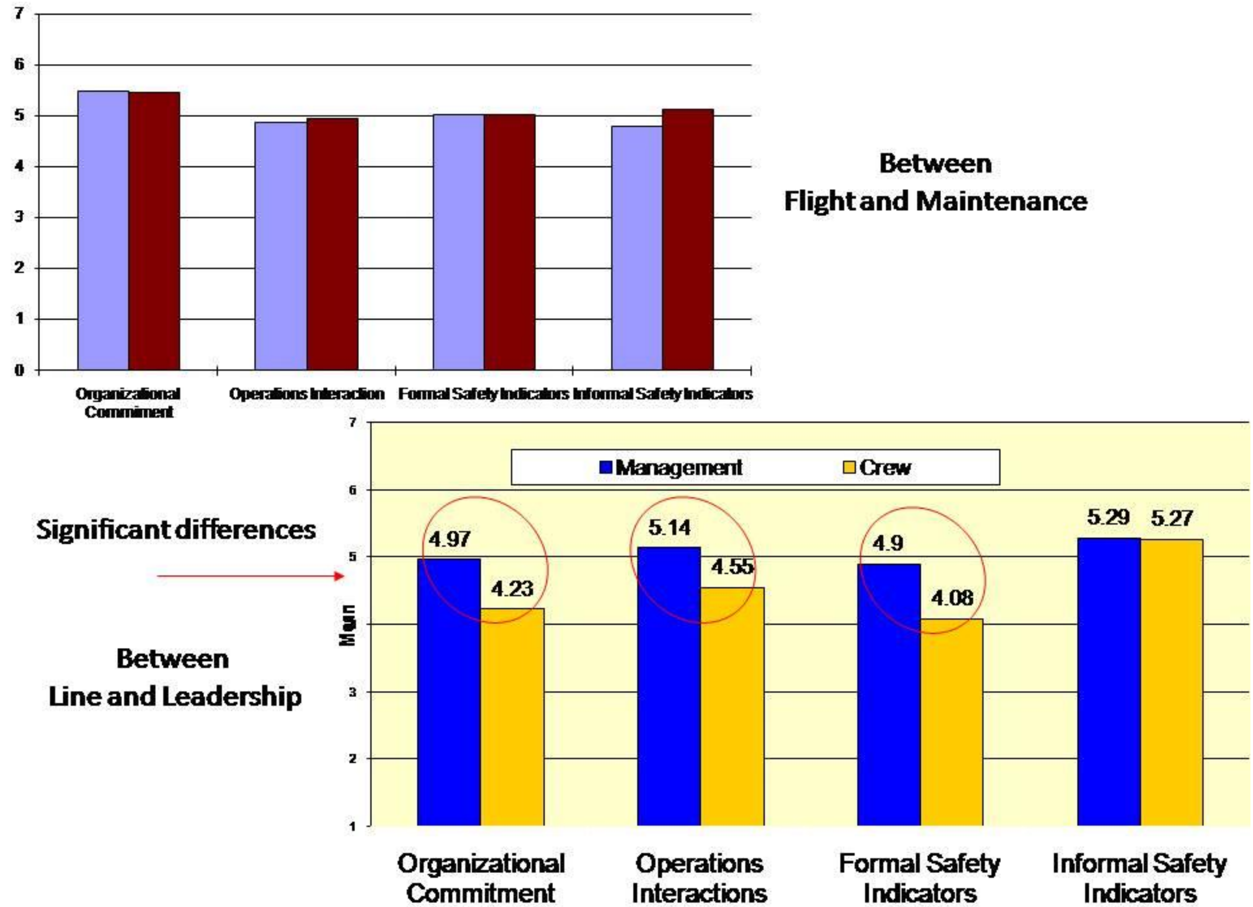

Figure 12. Example comparisons between flight and maintenance departments and line pilots and leadership using SCISMS.

Figure 13 illustrates slight differences in the indications of safety culture among pilots assigned to different fleet groupings at a major air carrier. While the differences are not considered statistically significant, figure 13 shows a consistent lower indication of the culture of safety among the fleet represented by the solid bars, than the fleet represented by the striped bars. This consistent lower indication of the safety culture exemplifies the persistent disparity pilots have experienced between the two types of fleets. Upon investigation, we discovered that the older fleet (solid bars, figure 13) represented a slightly lower indication of the safety culture, replete with inconsistencies in operational manuals and changes over time. The newer fleet (striped bars, figure 13) represents the more modern equipment and consistent training and operational materials, and thus a more satisfied grouping of pilots.

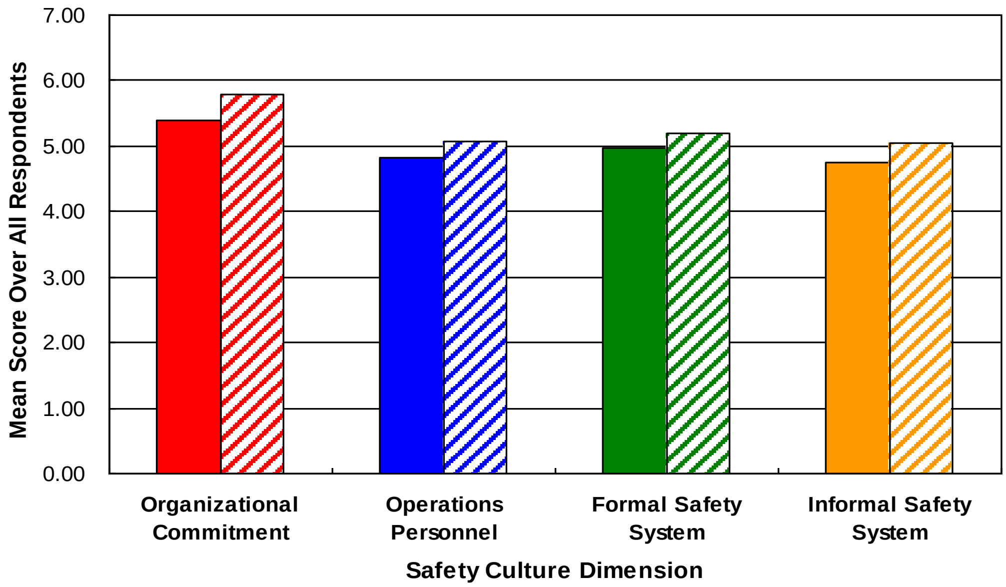

Figure 13. Fleet comparison among pilots at a major air carrier using SCISMS.

SCISMS has also been tested in foreign air carriers as well as domestic and international air carriers. Research continues into the baseline similarities and differences between the national and professional aviation cultures. Initial investigation reveals organizations facing similar global contextual factors relating to safety culture, yet with measurable differences in the relationships between departments and among subordinates, as seen as unique to each national culture. For example, table 4 compares the correlation scores between the major safety cultural factors and the safety behaviors measured by SCISMS in flight operations at a major US carrier and a comparable major European carrier.

Table 4. Example overall correlation scores between Major Factors and Safety Behavior for a Major US Carrier and a Major European Carrier .

Major US Air Carrier		**Major European Air Carrier**	
	Correlation (*r*)		Correlation (*r*)
Organizational Commitment	0.68	Organizational Commitment	0.58
Operations Interaction	0.53	Operations Interaction	0.65
Formal Safety Indicators	0.59	Formal Safety Indicators	0.59
Informal Safety Indicators	0.64	Informal Safety Indicators	0.66

All correlations significantly different from zero ($p<0.01$).

Correlations of safety behavior at the US air carrier are more highly associated with organizational Commitment (0.68) and Informal Safety Indicators (0.64), suggesting a top-down hierarchical significance toward safety activities at the air carrier. At the European air carrier correlations of safety behavior are more highly associated with Informal Safety Indicators (0.66) and Operations Interactions (0.65), suggesting safety practices may be more peer motivated. The loading of the items may be explained by in differences in national culture, as identified by Geert Hofstede (1990). Hofestede describes power distance as the extent to which less authoritative organizational members accept that power is distributed unevenly. A low power distance (as reflected by both the US and the European air carriers here) consists of associations that are more consultative or democratic. People relate to one another more as equals regardless of formal authoritative positions. Subordinates are more comfortable with contributing to and critiquing the decision making of those in power. Hofestede's Power Distance does not reflect an objective difference in power distribution but rather the way it is perceived.

6. THE SAFETY CULTURE GRID

Once the organizational scales are identified, the question arises as to how to relate the data back to an airline in a meaningful way that demonstrates the interrelationships among all of the organizational factors that are unique to the airline? Safety culture is best approximated on a multidimensional continuum or grid, as it falls outside the realm of a pyramid or linear configuration (Blake & Mouton, 1964). Rather, it exists within a continuum of related variables, factored in concert with managerial and employee perceptions that reveal the true structure of the organizational safety culture as it exists at the time of assessment. The Safety Culture Grid system is a representation of an organizational safety culture using data from the administration of the SCSIMS. This measure incorporates the global components of safety culture as they relate to operations assessed in the SCISMS: Organizational Commitment to Safety, Operations Interactions, Formal Safety Indicators, and Informal Safety Indicators. The grid system describes the overall state of safety culture in an organization and provides a means for organizational decision makers to identify the most appropriate safety management style and take proactive steps to improve safety. Safety management style is discussed in terms of the relationship between Management Involvement and Employee Empowerment. As in contingency theories (e.g., Fiedler, 1964), the effectiveness of a given style is contingent on the characteristics and objectives of the organization. Five possible styles are identified, and their implications for various types of organizations are discussed.

The Safety Culture Grid system incorporates a simple, visual strategy for assessing an organization's safety culture, identifying problems or areas for potential improvement, comparing the organization's current approach to safety culture with its desired approach, and tracking change over time. Using concepts from Blake and Mouton's, (1964) work on managerial style, safety culture may be best approximated on a multidimensional continuum using the perceptions (mean indicator responses) of line employees, plotted against the perceptions (mean indicator responses) of management (figure 14). Note that the SCISMS describes the population (culture), and not individuals within that culture.

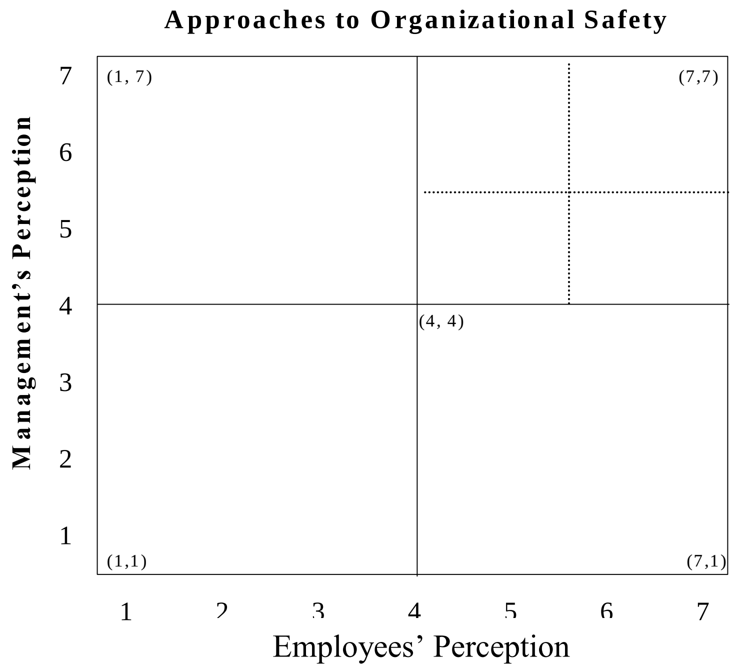

Figure 14. The Safety Culture Grid.

The overall grid is useful for characterizing an organization's safety culture at the global level. More in-depth analysis, however, is obtained by examining the specific items and their relationships. The utility of the grid lies in the ability to provide a general snapshot of the safety cultural indicators in the population. In particular, the difference or alignment in the relationship between management and employees can be used to determine the indications of an organization's safety management style. If these indicators are plotted against one another on subsequent grids, it is possible to define a general evolution of safety management. These indicators represent a model of the respective roles of management and employees in promoting and upholding the evolution of safety concepts in a manner analogous to Blake and Mouton's (1964) managerial grid. Understanding the organization's approach to safety management can clarify the indicative information provided in the overall grid.

The grid system allows the indicators of safety culture to be described in terms of three general features, consistency, direction and concurrence. Consistency refers to the dispersion of the indicator points. In a highly consistent safety culture, the points are clustered closely together, indicating roughly equal strength on all indicators. In a less consistent safety culture, the five points will be widely dispersed, suggesting that some indicators are more positive than others. Consistency is not necessarily a sign of a successful culture; it is possible to have a consistently poor safety culture or an inconsistent culture in which areas of strength compensate for weak points.

Direction describes the general location of the indicator points in terms of the grid. The central axes represent the neutral midpoint of the indicator scales. Points above the midpoint on both scales, that is, in the upper right quadrant, indicate that both management and employee respondents believe their organization generally displays more positive than negative examples of that indicator. Points in any of the other three quadrants are usually causes for concern. Points in the lower left quadrant, particularly, suggest that some organizational indicators may be consistent with a negative safety culture. These indicators should be examined carefully in light of the other indicators and features. For example, a high level of Professionalism may be able to compensate for a mediocre Reporting System. Extremely low scores on any indicator, however, are likely evidence of serious problems in need of attention.

The final feature, concurrence, is indicated in the grid by the proximity of the points to the diagonal or slope. Points on or close to the slope (concurrent indicators) indicate that managers and employees are aligned in their perceptions of the safety culture. Unlike the other two features, which are essentially neutral and descriptive, concurrence is a critical feature of a healthy safety culture, as it reflects the degree to which both managers and pilots share a common perception of the organization. Points above the diagonal indicate that managers perceive the safety culture more favorably than do line employees. This suggests that managers may be removed from and unaware of the safety issues actually faced by line employees, or that line employees may have unrealistic expectations regarding safety standards. Points below the diagonal indicate that line employees perceive the culture more positively than does management. This may occur when management fails to observe and recognize employee effort, or, conversely, when the standard expected by management is higher than that considered acceptable by employees. Any substantial lack of concurrence suggests that improving communication about safety issues, standards, and policies is necessary for improving the safety culture.

Safety culture must be driven by management. As a concept management must actively encourage, five ranges were originally identified on which to plot safety culture perceptions: Collaborative, Master Plan, Delegate-Safety-to-Others, Provisional/Avoiding, and Middle-of-the-Road. These ranges represent a fusion of strategic management science and organizational behavior principles (Brodwin & Bourgeois, 1984; Thompson & Strickland, 1993; von Thaden 2006). However, the argument can be made that organizational safety culture may be regarded as an evolutionary concept. To reflect this, von Thaden (forthcoming 2008) has redefined the concepts of Master Plan and Delegate-Safety-to-Others to Fixed and Drifting respectively, to reflect that organizational safety culture indeed evolves. The measurement of a culture of safety includes heritable characteristics (i.e., genotypes) that are detectable to some extent and represented in a meaningful way (i.e., phenotypes). These traits or characteristics represent the structure and influence of safety on the fitness of the organization, which may in turn be influenced by the environment, the operational technology, or the culture. Understanding the variance in these traits as they evolve provides researchers critical insight into the transmission of safety information, the development of a culture and the influence of safety. Ultimately, the heritability of safety behaviors and the survival of a culture of safety depend on the self-interest of the population, dependent upon the context of the safety structure in the organization as a whole.

Theories of evolution are well represented in the scientific literature (e.g., Malthus, 1826; Darwin, 1859; Johannsen, 1911; Mayr, 1982; Wood, 1988; Gould, 2002; Barbier, 2002). Since environments and populations can be observed to change over time, it is safe to say that the culture of safety may be affected by these changes and can also be observed to change over time. Understanding and explaining the characteristic nature of the changes requires observation and measurement over time. The process of how these changes evolve over time and affect the population are of central concern in this context of the term "evolution." Safety fitness may be represented differently under various environments. Detecting the structural traits of safety is determined by the fixity of their heritable characteristics in relationship to their interaction with and adaptation to the environment. Mapping the measured safety culture into the safety culture grid provides a snapshot of the indications that define a particular trait at any particular state of the organization's existence. This increases the information available to the organizational or regulatory leaders upon which to transmit recommendations. Organizational safety cultural indicators may change according to the internal stability of the population and external environmental variance affecting the population.

The grid system itself does not provide a measurement per se, but rather an indication or approximation of the measured safety characteristics of the organization, which should be viewed over time to reflect any variation in the measured culture on the whole. Variations in the culture or cultures eventually must be analyzed, using a consistent measurement system, to determine if the variations reflect inner-organizational effects, influence from the external environment, or a combination of both. Below are the descriptions of the plotted quadrants employed in the Safety Culture Grid system's multidimensional continuum, succinctly listed in table 5.

(7, 7) *Collaborative*

In a Collaborative safety culture, safety is seen as a primary integrated concern throughout the organization. Management enlists the help of key employees in developing a consensus plan for safety that all employees will endorse and do their best to implement successfully. Organizational leadership encourages employees to share in decision-making and problem solving, and keeps employees informed about matters that affect them. Each person in the company shares in the implementation of the safety plan (shared vision). Leaders are visible and approachable. Employees have ownership in the plan and a stake in proactively committing to its successful execution. Since employees have ownership, they can also be held accountable for assuring safety works and are empowered to evaluate their own performance. This collaborative culture successfully combines appropriate fixity and adaptation so that safety is institutionalized and well-grounded in the operating procedures. A generative approach.

(1, 7) *Fixed*

In a Fixed culture of safety there exists a type of master plan for safety. Management exercises strong influence over the details and alternatives in the organization's safety strategy; a by-the-book, idealized leadership committed to enforcing rules and auditing behavior is employed. Safety policies and procedures are designed for a well-functioning, cohesive environment and do not necessarily change or adapt to the current operational environment, even when the utility of the feature is unknown or ceases to be practical. Employees may be at a loss to understand the reasons for certain procedures. Policies may exist without explanation, e.g., "We've always done it this way," and there is a distinct difference between the operational reality and the safety policy. Variations in the aviation environmental operation are seen as inconsequential. Management may act as guiding leader and has a large ownership stake in the chosen safety plan (achievement oriented). Management is calculative, having a rule or system in place to manage threats (hazards) and does not consult employees about their safety concerns. This approach can be effective in areas where employees have little insight into the global aspects of the operation. Employees here need to operate by-the-book with regard to standards and procedures, such as handling delicate or dangerous equipment or performing repetitive tasks. Paradoxically, employees may be resistant to change, preferring to exploit their stronghold on the procedures. This may be ineffective when flexible decision-making is needed to break routines that are no longer useful, resulting in employees doing only what is expected of them and nothing more.

(7, 1) *Drifting*

In this safety culture, the development of safety strategy usually rests with the employees and is often compelled by the environment. Advantageous safety traits offering some improved function are reproduced to become more common and frequently practiced throughout the population. Employees determine their safety goals, make decisions and resolve problems on their own. The culture may be based on employee personal experience, judgment, and local effort rather than technological aids or formal plans (a "seat-of-the-pants" approach). A "what works" for now approach that is well-fitted to the function may be reproduced by the employees if it provides the favorable means to resolve problems or responds to changes in the operational environment. These practices enable the working population to cope with the operational stresses and pressures. Over time, the approaches to safety may be specifically adapted differently for each population, i.e., base of operations, or specific job niche. Management stays distant, keeping in touch via reports or conversations, offering guidance if needed, reacting to informal "trial" recommendations, and perhaps approving a plan after it has been formally presented, discussed, and a consensus emerges from the employees (laissez faire or hands off). Management rarely has much ownership in the recommendations and privately may not see much urgency to implement some or much of what has been written in the company's official plan. In extremely adaptive situations (wherein much of the safety strategies have been delegated to the employees), rarely are the returns from simply one adaptive safety procedure enough to build a new systemic safety process, rather they are weighted against other adaptations which consequently cannot change without affecting other parts of the system. Variants in the operational environment may arise indiscriminately and thus adaptive procedures can randomly occur. Since the aviation operational environment is constantly fluctuating, the utility of adaptive processes and behaviors are thus instable. It is nearly impossible to maintain a beneficial locally adaptive safety culture without inviting maladaptive mechanisms. Changing to adapt to one method may mean less ability to adapt to another method, reducing the strength of the organization's systemic safety culture. An adaptive style may prove effective in a company where the employees are highly skilled, educated and motivated. However, some employees may feel insecure at the lack of supervisory availability, and managers may not be able to provide feedback to employees regarding their safety performance, or be able to thank employees for a job well done. This hands-off approach may also conceal poor management. This tends to be a local, rather than a global corporate approach.

(1,1) Provisional/Avoiding

In a Provisional or Avoiding safety culture, management expects employees to implement safety strategies and employees expect management to take responsibility. Management is neither interested in crafting the details of safety policy nor in the time-consuming task of reaching consensus with employees. Management does not consult employees, nor do employees give input. When needed, management "tells" employees how safety should be managed, but largely it remains undefined. Safety is viewed within the confines of the immediate task at hand, without consideration for the organization as a whole. Often any safety strategy is temporary and reactive; it deals more with today's problems than with instilling the organization with enduring safety values. Employees may become accustomed to modifying, adjusting and reworking processes on-the-fly (e.g., what "gets the job done"); however this may prove harmful to the ultimate goals of system safety. Certain alterations may appear useful at the time they are employed, but may ultimately prove maladaptive, or harmful, in reference to the balance of system safety or over time. Maladaptive behaviors or processes survive if they become accepted mechanisms of practice in organizations with little historic standard safety grounding. However, if these less appropriate maladaptive processes eventually prove dysfunctional they may become abandoned for the next flavor-of-the-day. In a provisional safety culture, accidents and incidents are seen as part of the job, with temporary or reactive fixes resulting. Employees are expected to follow safety policies without explanation, and stay motivated through a prearranged set of rewards and punishments that may be dispensed at will. This may prove ineffective with employees who expect their managers to make their decisions, or need their work coordinated with other departments or organizations. There is low organizational commitment with highly centralized management. Safety may be carried out through an existing policy whether it works or not. Safety is a byproduct. A highly reactive approach.

(4,4) *Middle-of-the-Road*

When there are several different versions of the safety culture in the population, manifesting toward neutrality, it may be a result of drifting safety policies or populations at odds. In a Middle-of-the-Road safety culture, the goal may be to find a central ground or to be yielding. It may indicate the lack of bold, thoughtful initiative. This may also represent political consensus with the outcome shaped by influential subordinates, powerful departments, or majority coalition that have a strong stake in promoting their own version of what the safety policy ought to be. Politics and power plays may be strongly indicated in an environment where there is no consensus on which strategy to adopt. It may also suggest that variation in the adaptation of safety culture in an organization has drifted so that several different constructs, possibly at odds with each other, are equally adept at providing for the safety goals in an organization. Since this represents a neutral mechanism, which safety construct is followed does not affect the ultimate safety consequence.

Table 5. Summary of Organizational Types measured using SCISMS.

Organizational Type	*Key Factors*
Collaborative	− High assertiveness and high cooperation, − Employee/management established goals, − Recognizes and encourages personal responsibility for safety, − Esprit de corps, − Employees responsible to evaluate their own performance, − Seeks to improve, learn, − Recognizes change and seeks input to ensure safety outcomes, − Looks for ways to develop win-win situations, − Flexible, generative.
Fixed	− Master plan for safety/high managerial assertiveness, − Means of ensuring safety performance = by-the-numbers, − Conservative decision-making, slow to recognize change, − Operates by detailed procedures/instructions/measures, − Predetermined, work carried out according to traditional procedure or policy, − Safety-by-the-Rules, calculative, − Immutable, inflexible, "We've always done it this way."
Drifting	− Safety is devolved to employees/high employee assertiveness, − Employees set safety standards, − Based on personal experience, adapts to environment/ population, − Based on personal experience, − Laissez faire management.
Provisional/Avoiding	− Avoidance: low assertiveness, low cooperation, − Do-it-yourself, − Ad-hoc, unplanned, vague, reactive, − Workers modify, adjust, and rework safety on-the-fly, − Little to no coordination.
Middle-of-the-Road	− Compromising a moderate assertiveness and cooperation , − Accommodating: low assertiveness, high cooperation.

6.1 Safety Culture Profile.

Using the mean values scored from the SCISMS, the airline's safety culture factors may be plotted into the grid (figure 15), demonstrating an organization with a collaborative safety environment. This placement indicates that the overall safety culture at the airline generally espouses a positive safety culture that tends toward the middle of the road, with high scores in safety behavior albeit more so driven by line pilots.

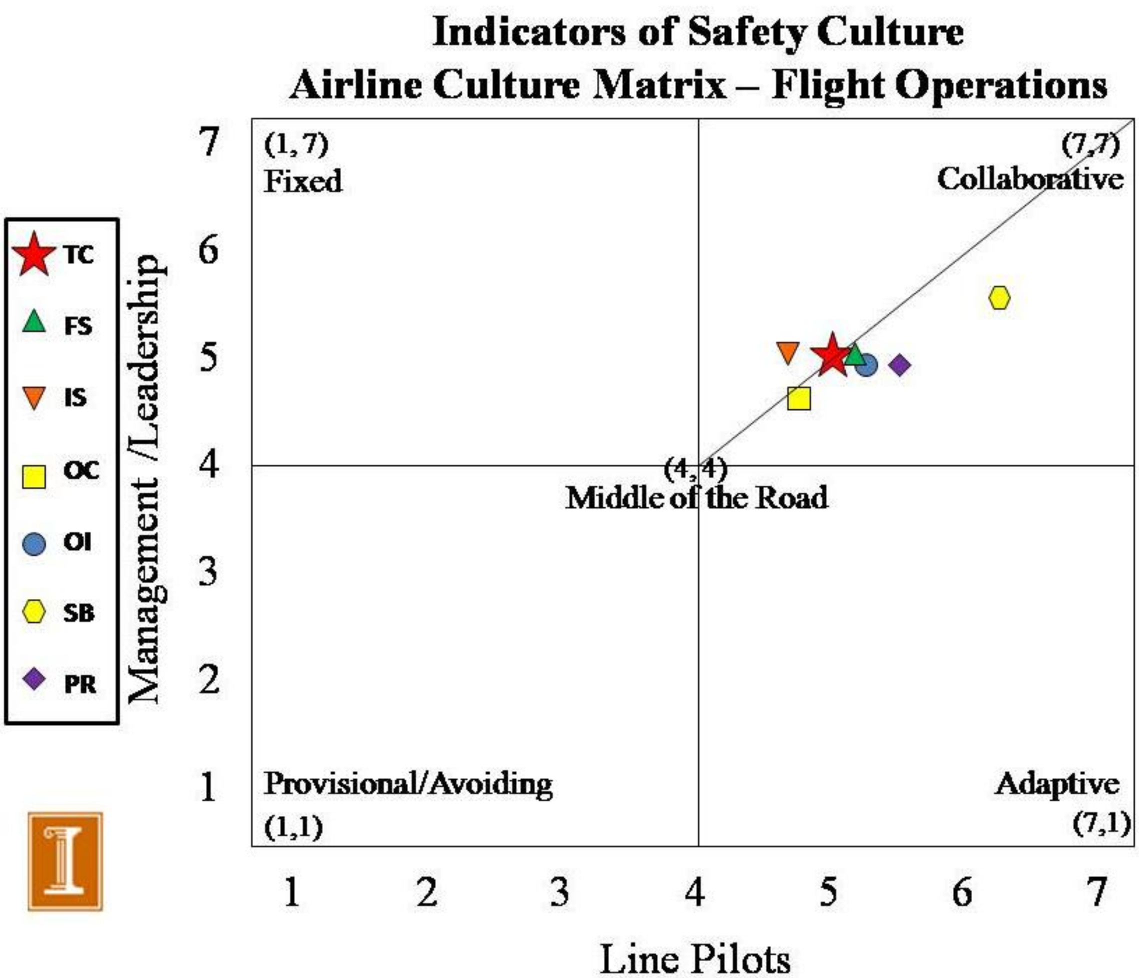

Figure 15. Safety Culture as it is plotted at airline flight operation's department.
TC= Total Safety Culture Indicator, FS=Formal Safety Indicators, IS=Informal Safety Indicators, OC=Organizational Commitment, OI=Operations Interactions, SB=Safety Behavior, PR = Perceived Organizational Risk.

Figure 16 depicts the airline's total safety culture score as plotted against other major air carriers' flight operations departments who have participated in the SCISMS over the past year. The airline's indicators of safety culture for flight operations are in line with other similar aviation organizations' indicators of safety culture.

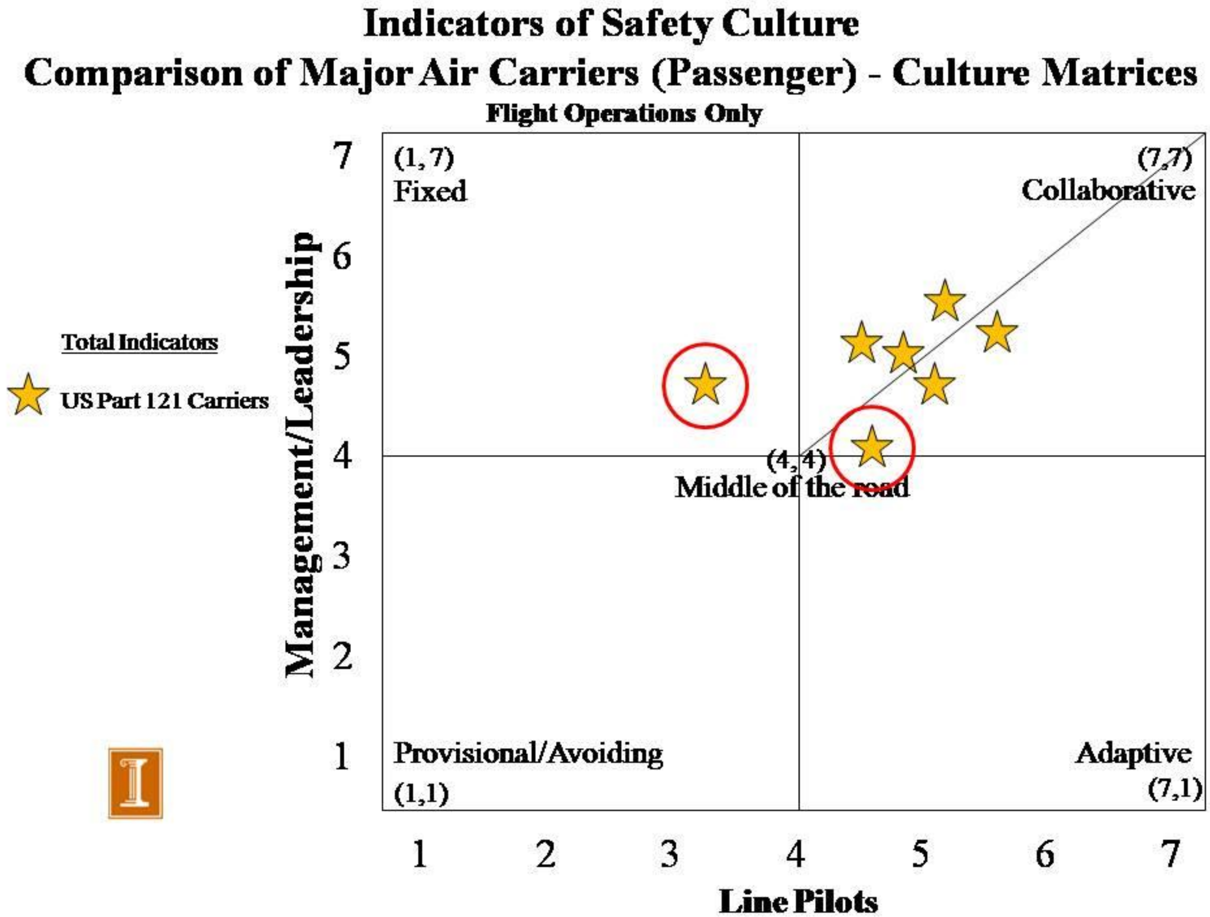

Figure 16. Airline Total Safety Culture Indicator plots for US Part 121 major passenger air carrier flight operations departments surveyed during the same time period in 2007-2008.

The air carriers participating in the SCISMS thus far, in anticipation of SMS, have tended to display more proactive collaborative safety cultures. However, as shown by the total score results of the SCISMS, demonstrable differences exist between the measured safety culture in US Part 121 air carriers. While most of the carriers display fairly aligned collaborative safety cultures (along the slope) with room for some improvement, two of the carriers displayed misaligned safety cultures (red circles) that would benefit from intervention.

Figure 17 shows a comparison of total safety culture score indicators of US and EU air carrier flight operations departments who have participated in the SCISMS over the past year. The US and EU carriers indicators of safety culture for flight operations are in line with other similar aviation organizations' indicators of safety culture, displaying a generally aligned collaborative safety culture with room for improvement in specific areas.

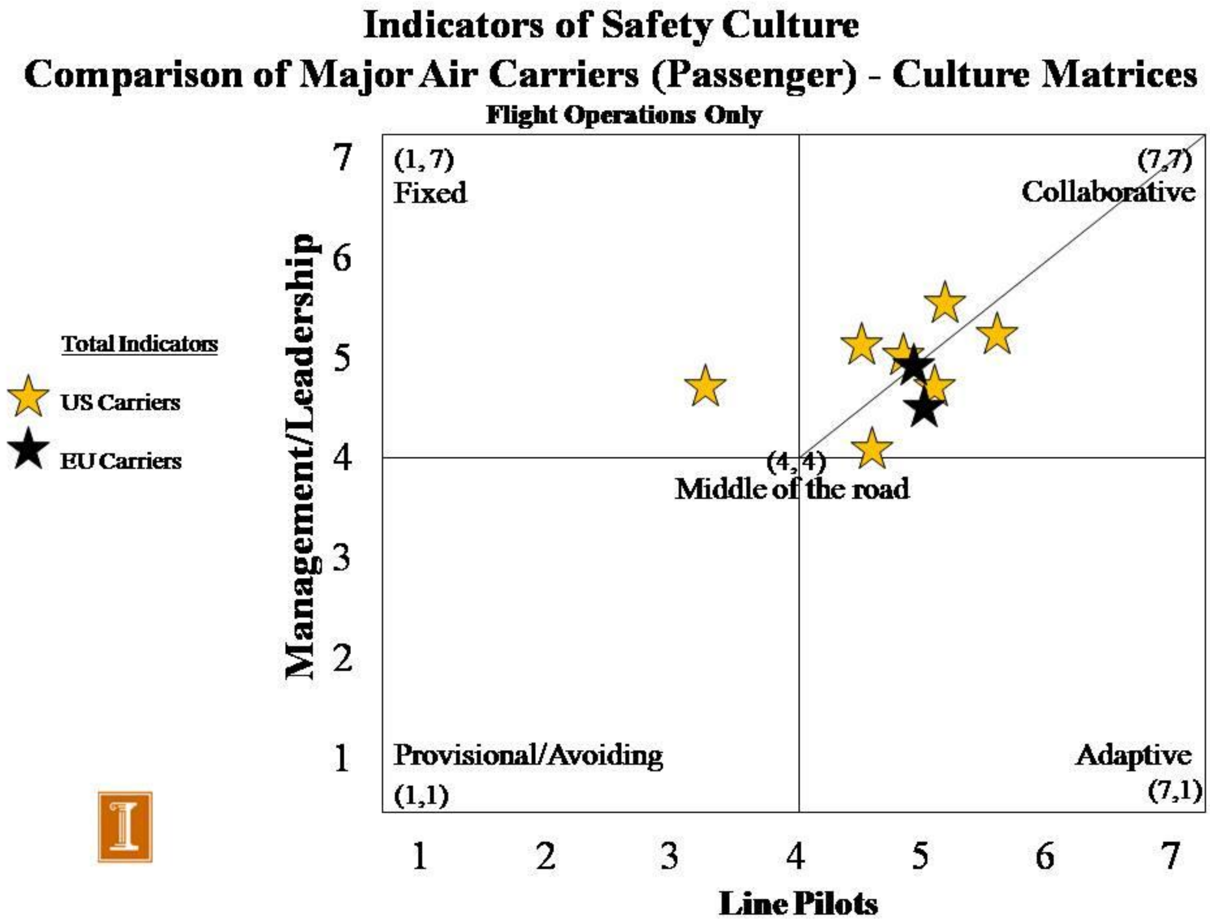

Figure 17. Airline Total Safety Culture Score Indicator plots for US and EU major passenger air carrier flight operations departments surveyed during the same time period in 2007-2008.

Figure 18 illustrates the total safety culture score indicators for each operational department at a US Part 121 air carrier using SCISMS. Maintenance operations appear generally collaborative and well aligned within the department. However each of the other departments surveyed with SCISMS, flight operations, dispatch operations, cabin operations, and ramp operations, display misaligned cultures of safety in regard to procedures, practice and policy. The gaps in measured safety culture between the departments demonstrate there is not a unified practice of safety ideals within the carrier. In fact, ramp and cabin operations are in critical need of intervention to move the culture toward positive alignment.

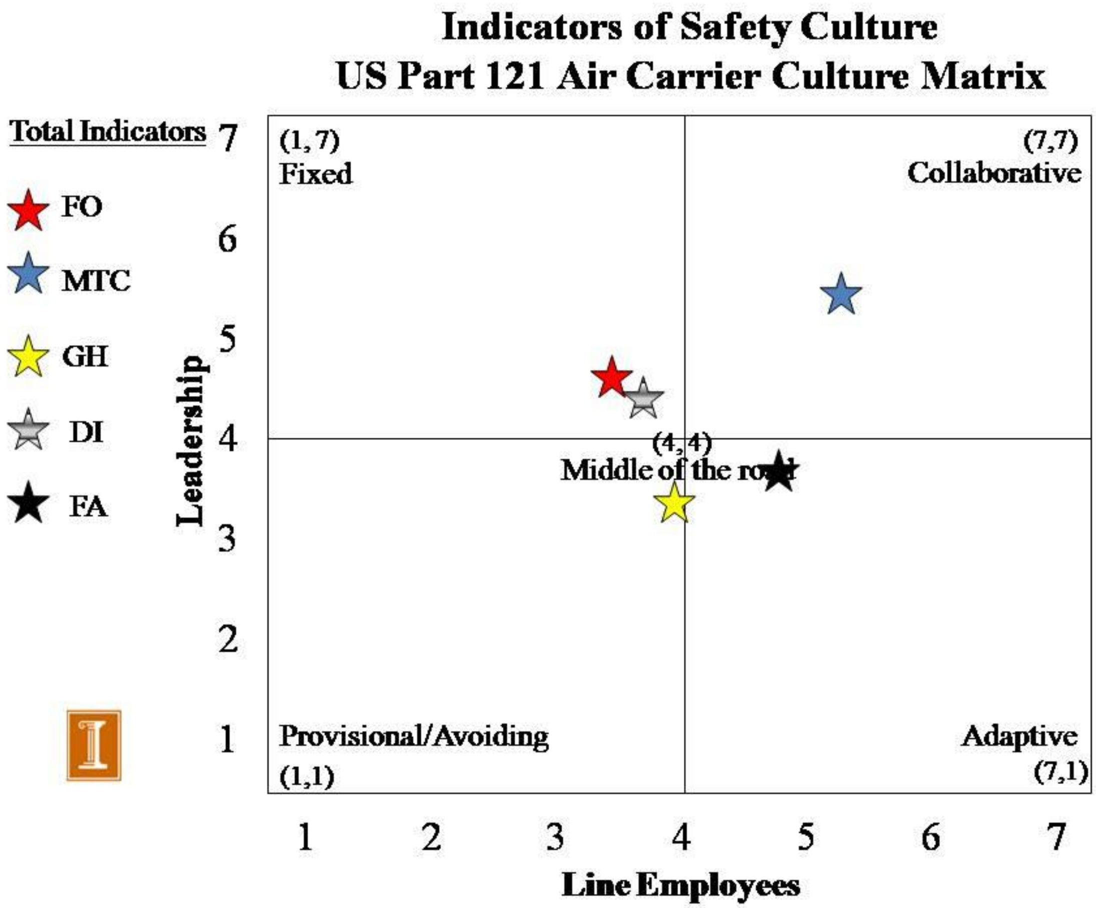

Figure 18. Airline Total Safety Culture Score Indicator plots for each operational department surveyed at a major US Part 121 passenger air carrier.
FO = Flight Operations, MC = Maintenance Operations, GH = Ground Handling Operations, DI = Dispatch Operations, FA=Cabin Operations.

Figure 19 shows the results from the SCISMS disseminated in a maintenance operation over the course of subsequent years.

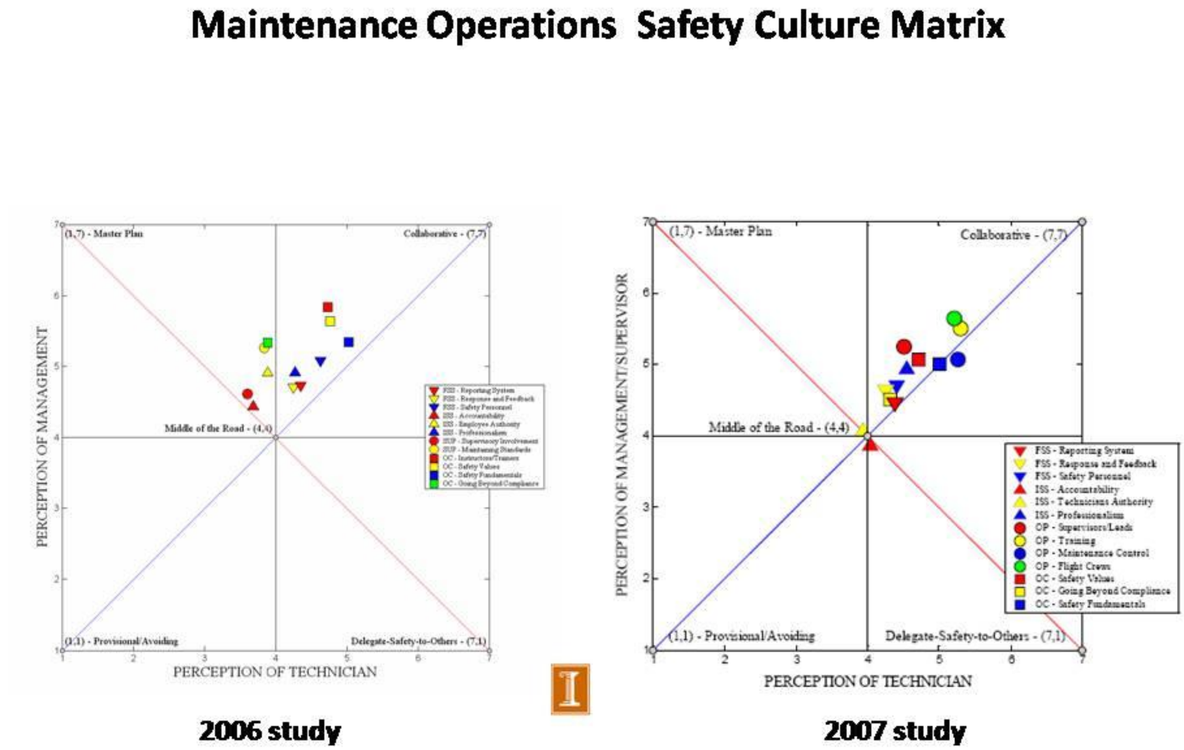

Figure 19. Measured safety culture change at maintenance facility, using SCISMS

Using the mean values scored from the SCISMS (figure 19), the organization's safety culture indicators demonstrate an organization with a fairly collaborative safety environment, albeit more driven by fixed concepts of safety. This placement indicates that the overall safety culture at the maintenance facility generally espouses a safety culture that is driven by management policy and displays gaps in the alignment of the organization's overall safety culture. After the organization received a measurement report and changed aspects of operations based on recommendations from the report, the cultural environment was observed to shift into alignment quite markedly toward a collaborative culture of safety when measured in the following year.

When interested in improving the culture of safety in an organization, the knowledge of the measured safety indicators allows for the selection of specific traits to increase or decrease to promote change in the culture. The rate of change may be low for some populations, and rapid for others, thus continual measurement of the population is necessary to determine the subsequent consistency of the culture.

7. CONCLUSIONS.

This document described a method to assess indicators of safety culture in Part 121 aviation operations. The methodology was validated through the voluntary participation of federally certified air carriers. This document presented aggregate data results obtained from using this methodology. Also presented was an overview of data results collected using the Safety Culture Indicator Scale Measurement System (SCISMS) in Part 121 operations.

The SCISMS approach is flexible and consistent. Survey items can be varied to capture the specific conditions of each operational unit, but the overall framework remains constant. This means that individual departments or units can receive detailed, specific feedback (rather than feedback based on a set of broad, one-size-fits all items), but the overall results are presented in a common language to facilitate comparisons and transmission of information. This approach has allowed organizations to be studied over time and compared across operations.

The SCISMS approach fuses techniques to measure both the organizational safety culture and the professional safety climate at aviation organizations. A critical precept in the concept of organizational safety culture is the ability to measure the evolution of organizational safety. To validate the measurement system, data must be assessed from closely related populations (e.g., within an organization) and more distantly related populations (e.g., a group of organizations with a similar charter). Given the complexity of the populations and the environment of the aviation industry, unique indicators of the safety culture may be reflected at different times. Thus a standardized longitudinal measurement system is critical to consistently collect data for each individual organization, as well as the industry as a whole to predict the outcomes of a safety culture in safety management systems with certainty. The concept of a standard metric is critical because as the conduct of aviation business, safety management systems, and the concept of safety culture evolve in aviation organizations, so must the measurement system. What we measure today, may not be relevant in the aviation system ten years from now, and the measurement tools must reflect that change and demonstrate the path toward certain items have been dropped and newer items have been added. For example, as aviation organizations realize cost savings by outsourcing certain processes, so do relationships change within the company. These associations must be made clear when surveying the organization's population.

SCISMS has verified its utility and reliability as a system measurement tool. In order to predict outcomes of organizational safety culture, indicators of the safety culture must be correlated with other data collected in a safety management system. Further verification of the model of safety culture presented here requires additional longitudinal study of Part 121 operations and broad application to other aviation institutions. Study currently continues among certified air carriers and other industry partners to test both theory and application of the principles contributing to organizational safety culture. Consistent measurement of cultural distinctions allows organizations to perform self-assessment and the FAA to gauge the general safety culture of the industry without exposing protected individual data. These aggregate data provide critical industry criteria for baseline measures and benchmark standards of safety culture. Dr von Thaden continues her work in this area, as well as the development of models of the evolution of safety culture and the sharing of safety information.

REFERENCES.

Airports Council International (ACI). (2007). *Global traffic forecast 2006-2025*. Executive Summary. Geneva Switzerland. Available at: http://www.airports.org/.

Barbier, M. (2002) *The organic codes: an introduction to semantic biology*. Cambridge University Press.

Barling, J., and Frone, M.R. (2004). The psychology of workplace safety. Washington, DC: American Psychological Association.

Barling, J., Loughlin, C., and Kelloway, E. (2002). Development and test of a model linking safety-specific transformational leadership and occupational safety. Journal of Applied Psychology 87(3), 488-496.

Bird, F. (1974). *Management guide to loss control.* Atlanta, GA: Institute Press.

Blake, R. R. and Mouton, J. S. (1964). *The managerial grid, key orientations for achieving production through people*. Houston, TX: Gulf Pub. Co.

Boeing, 2007. Statistical summary of commercial jet airplane accidents worldwide operations 1959 -2006. July, Seattle, WA.

Brodwin, D. R., and Bourgeois, L. J. (1984). Five steps to strategic management. In G. Carroll & D. Vogel (Eds.), *Strategy and organization: A west coast perspective* (pp. 168-178). Marshfield, MA: Pittman Publishing.

Cooper, M. D. (2000). Towards a model of safety culture. *Safety Science, 36*(2), 111-136.

Cooper, M., and Phillips, R. (2004). Exploratory analysis of the safety climate and safety behavior relationship. *Journal of Safety Research 35*(5), 497-512.

Cox, S., and Cheyne, A. (2000). Assessing safety culture in offshore environments. *Safety Science 34*(1-3), 111-129.

Cox, S., and Flin, R. (1998). Safety culture: Philosopher's stone or man of straw? *Work & Stress, 12*(3), 189-201.

Creswell, J.W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334.

Darwin, Charles (1859) *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life*. London: Murray. Available online at :www.darwin.org.uk

Deal, T. E., and Kennedy, A. A. (1983). Culture: A new look through old lenses. *Journal of Applied Behavioral Science, 19* (4), 498-505.

Dedobbeleer, N., and Beland, F. (1991). A safety climate measure for construction sites. *Journal of Safety Research, 22,* 97-103.

Doran, D. (2008). Airbus: World will order 24,300 planes by 2026. *USA Today*, 8 February. Downloaded 11 February 2008, from: http://www.usatoday.com/travel/flights/2008-02-08-airbus-forecast_N.htm.

FAA (2006). *Introduction to safety management systems for air operators*. Advisory Circular 120-92.

FAA (2008). SASO Outreach. *Quarterly Update of SASO activities*, June 2008. http://www.faa.gov/safety/programs_initiatives/oversight/saso/news/media/saso_newsletter_june_2008.pdf

Fiedler, F. E. (1964). A contingency model of leadership effectiveness. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (pp. 150-190). NY: Academic Press.

Flin, R., Mearns, K., O'Connor, P., and Bryden, R. (1998). Measuring safety climate: Identifying the common features. *Safety Science, 34*(1-3), 177-192.

Gaba, D. M., Singer, S. J., Sinaiko, A. D., Bowen, J. D., and Ciavarelli, A. P. (2003). Differences in safety climate between hospital personnel and naval aviators. *Human Factors 45*(2), 173-185.

Gibbons, A. M., von Thaden, T. L. and Wiegmann, D. A. (2004). Exploration of the correlation structure of a survey for evaluating airline safety culture. *University Technical Report AHFD-04-06/FAA-03-03.* Prepared for the Federal Aviation Administration, contract DTFA 01-G-015.

Gibbons, A., von Thaden, T. and Wiegmann, D. (2006) Development and initial validation of a survey for assessing safety culture within commercial flight operations. *International Journal of Aviation Psychology*, 16 (2), NJ: LEA.

Glaser, B.G., and Strauss, A.L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago: Aldine.

Glendon, A.I., and Stanton, N.A. (2000). Perspectives on safety culture. *Safety Science, 34*(1-3), 193-214.

Gould, S. (2002). *The structure of evolutionary theory.* Harvard: Bellknap.

Griffin, M. A. and Neal, A. (2000). Perceptions of safety at work: A framework for linking safety climate to safety performance, knowledge, and motivation. *Journal of Occupational Health Psychology 5*(3), 347-358.

Guldenmund, F.W. (2000). The nature of safety culture: A review of theory and research. *Safety Science 34*(1-3), 215-257.

Guldenmund, F. W. (2007). The use of questionnaires in safety culture research - an evaluation. *Safety Science, 45*(6), 723-743.

Heinrich, H.W. (1959). *Industrial Accident Prevention* New York, McGraw Hill Book Company.

Heinrich, H., Petersen, D., and Roos, N. (1980). *Industrial accident prevention: A safety management approach* (5th edition). New York: McGraw Hill.

Helmreich, R. L. and Merritt A.C. (1998). Organizational culture. In R. L. Helmreich & A. C. Merritt (Eds.), *Culture at work in aviation and medicine* (pp. 107-174). Brookfield, VT: Ashgate.

Hofstede, G. (1990). *Cultures and Organizations: Software of the Mind*. McGraw-Hill, London.

ICAO, (1993). *Human factors digest No 10, human factors, management and organization.* Circular 247. International Civil Aviation Organization, Montreal.

Johannen W. (1911). The genotype conception of heredity. *American Naturalist* 45, 129-159.

John, O. P., and Benet-Martinez, V. (2000). Measurement: reliability, construct validation, and scale construction. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology.* New York: Cambridge University Press.

Joint Aviation Authorities (JAA, 2006). *JAR-FCL1 Flight Crew Licensing (Airplane): Amendment 7.* Report number 09/44-1/06-L598. The Netherlands: JAA.

Karp, A. (2008; June). Recovery comes to a crashing halt. *Air Transport World* (www.atwonline.com/channels/dataAirlineEconomics/article.html?articleID=2356).

Kern, T. (2001) *Controlling pilot error: culture, environment, and CRM.* McGraw-Hill.

Lee, T. and Harrison, K. (2000). Assessing safety culture in nuclear power stations. *Safety Science, 34*(1-3), 61-97.

Li, Y., von Thaden, T., Li, F., Jang, L., and Dong, L. (2007). Validating the commercial aviation safety survey in Chinese cultural context: a case study. *In Proceedings of the Safety Across High-Consequence Industries Conference,* St. Louis, MO, March 13-15.

Lin, S-H., Tang, W-J., Miao, J-Y., Wang, Z-M. and Wang P-X. (2007). Safety climate measurement at workplace in China: A validity and reliability assessment. *Safety Science*, *46*(7), 1037-1046.
Malthus, T.R. (1826). *An essay on the principle of population: a view of its past and present effects on human happiness; with an inquiry into our prospects respecting the future removal or mitigation of the evils of which it occasions*. (6th ed). London: John Murray.

March, J., and Simon, H. (1958). *Organizations.* New York: Wiley.

Maurino, D.E., Reason, J., Johnston, N., and Lee, R. (Eds.) (1995). *Beyond aviation human factors, safety in high technology systems*. United Kingdom: Ashgate.

Mayr, E (1982). *The growth of biological thought: Diversity, evolution, and inheritance,* Harvard University Press.

McDonald, R. P. (1999). *Test theory: A unified treatment*. Mahwah, NJ: Lawrence Erlbaum.

McDonald, N., Corrigan, S., Daly, C., and Cromie, S. (2000). Safety management systems and safety culture in aircraft maintenance organizations. Safety Science 34(1-3), 151-176.

Mearns, K. J., and Flin, R. (1999). Assessing the state of organizational safety--Culture or climate? *Current Psychology: Developmental, Learning, Personality, Social, 18*(1), 5-17.

Mearns, K., Flin, R., Gordon, R., and Fleming, M. (1998). Measuring safety climate on offshore installations. *Work & Stress 12*(3), 238-254.

Meshkati, N. (1997, April). *Human performance, organizational factors and safety culture.* Paper presented on National Summit by NTSB on transportation safety, Washington, D.C.

National Transportation Safety Board. (1992). *Aircraft Accident Report. Britt Airways, Inc., d/b/a Continental Express Flight 2574, In-flight Structural Breakup, EMB-12ORT, N33701, Eagle Lake, Texas, September 11,199l* (Rep. No. NTSB/AAR-92/04). Washington DC: Author.

Neal, A. and Griffin, M. (2006). A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. *Journal of Applied Psychology, 91*(4), 946-953.

Neal, A., Griffin, M.A. and Hart, P.M. (2000). The impact of organizational climate on safety climate and individual behavior. *Safety Science*, *34*(1-3), 99–109.

O'Toole, M. (2002). The relationship between employees' perceptions of safety and organizational culture. *Journal of Safety Research*, *33*(2), 231-243.

Probst, T. M., Brubaker, T. L., and Barsotti, A. (2006, April). Organizational injury rate under-reporting: The moderating effect of organizational safety climate. *Paper presented at the Society for Industrial-Organizational* Psychology, Dallas, TX.

Reason, J. (1990). *Human error*. Cambridge: Cambridge University Press.

Reason, J. (1997). *Managing the risks of organizational error.* Brookfield, VT: Ashgate.

Reiman, T. and Oedewald, P. (2007). Assessment of complex sociotechnical systems: theoretical issues concerning the use of organizational culture and organizational core task concepts. *Safety Science*, *45*(7), 745-768.

Rose, N.L. (1991). *Fear of flying?* Economic analysis of airline safety. NBER Working Paper No. W3784).

Rundmo, T. (2000). Safety climate, attitudes, risks, and perceptions in Norsk hydro. *Safety Science*, *34*(1-3) 47-59.

Schein, E. H. (1991). What is culture? In P. J. E. Frost, L. F. E. Moore, M. R. Louis, C. C. Lundberg, & J. Martin (Eds.), *Reframing organizational culture* (pp. 243-253). Newbury Park, CA: Sage Publications.

Silva, S., Lima, M.L. and Baptista, C. (2004). OSCI: an organizational and safety climate inventory. *Safety Science*, *42*(3), 205-220.

Smircich, L. (1983). Concepts of culture and organizational analysis. *Administrative Science Quarterly*, *28*(3), 339-358.

Smith, G. S., Huang, Y.-H., Ho, M., and Chen, P. Y. (2006). The relationship between safety climate and injury rates across industries: The need to adjust for injury hazards. *Accident Analysis & Prevention 38*(3), 556-562.

Sorensen, J.N. (2002). Safety culture: a survey of the state-of-the-art. *Reliability Engineering and System Safety, 76*, 189-204.

Spielberger, C. D. (Ed.) (1966). *Anxiety and behavior*. New York, NY: Academic Press.

Suchman, L. (1987). P*lans and situated actions: The problem of human-machine communication*. New York, NY: Cambridge University Press.

Thompson, A.A., Jr., and Strickland, A.J. (1993). *Strategic management: Concepts and cases.* Boston, MA: Irwin.

Varonen, U., and Mattila, M. (2000). The safety climate and its relationship to safety practices, safety of the work environment and occupational accidents in eight wood-processing companies. *Accident Analysis & Prevention 32*(6), 761-769.

von Thaden, T.L. (2008). *Safety culture in commercial aviation operations.* University of Illinois Human Factors Division Technical Report HFD-08-3/FAA-08-1. Prepared for the Federal Aviation Administration, contract DTFA 01-G-015.

von Thaden, T. L. (2008). Distributed information behavior: a study of dynamic practice in a safety critical environment. *The Journal of the American Society for Information Science and Technology*. *59*(10), 1555-1569. NJ: Wiley.

von Thaden, T.L. and Hoppes, M. (2005). Measuring a just culture in healthcare professionals: Initial results from a survey. *Proceedings of the Safety Across High-Consequence Industries Conference.* Paper Number 2005-02-027. St. Louis, Missouri. September 20-22, 2005.

von Thaden, T. L., Hoppes, M., Johnson, N., Li Y. and Schriver, A. (2006). The perception of just culture across disciplines in healthcare. *Health Care Technical Group The Proceedings of the 50th Annual Human Factors and Ergonomics Society Conference,* San Francisco, CA, Oct 2006.

von Thaden, T.L., Li, Y., Li F., Jiang L., and Dong, L. (2006). *Validating the Commercial Aviation safety survey in the Chinese context.* University of Illinois Human Factors Division Technical Report HFD-06-09. Prepared for the Federal Aviation Administration, contract DTFA 01-G-015.

von Thaden, T.L. and Gibbons, A.M. (2007). Safety Climate – One Construct Fits All? *22nd Annual Conference of the Society of Industrial and Organizational Psychology (SIOP)* New York, New York, April 27-29.

von Thaden, T.L., Gibbons, A.M. and Li, Y. (2007). *Measuring safety culture in airline maintenance operations*. University of Illinois Human Factors Division Technical Report HFD-07-4/FAA-07-3. Prepared for the Federal Aviation Administration, contract DTFA 01-G-015.

von Thaden, T.L. and Li, Y. (2008). Attitudes of Chinese commercial pilots toward voluntary reporting systems. *XXIX International Congress of Psychology*. Berlin, Germany, July 20-25, 2008.

von Thaden, T. L., Kessel, J, and Ruengvisesh, D. (2008). Measuring Indicators of Safety Culture in a Major European Airline's Flight Operations Department. *The Proceedings of the 8th International Symposium of the Australian Aviation Psychology Association*. Novotel Brighton Beach, Sydney, 8 - 11 April.

von Thaden, T., Wiegmann, D. and Shappell, S. (2006). Organizational factors in aviation accidents. *International Journal of Aviation Psychology*, 16(3), 239-255, NJ: Lawrence Earlbaum Associates.

Vredenburgh, A.G. (2002). Organizational safety: which management practices are most effective in reducing employee injury rates? *Journal of Safety Research*, *33*, 259–276.

Wallace, J. C., and Chen, G. (2006). A multilevel investigation of personality, climate, self-regulation, and performance. *Personnel Psychology 59*, 529-557.

Weick, K. E. (1987). Organizational culture as a source of high reliability. *California Management Review, 29*(2), 112-127.

Wiegmann, D. A. and Shappell, S. A. (2003). *A human error approach to aviation accident analysis: The human factors analysis and classification system.* Burlington, VT: Ashgate.

Wiegmann, D. A., Zhang, H. and von Thaden, T. L. (2001). Defining and assessing safety culture in high reliability systems: an annotated bibliography. *University of Illinois Aviation Research Lab Technical Report ARL-01-12/FAA-01-4.*

Wiegmann, D., Zhang, H., von Thaden, T., Sharma, G. and Mitchell, A. (2002). A synthesis of safety culture and safety climate research. *Technical Report ARL-02-3/ FAA-02-2*. Prepared for the Federal Aviation Administration, contract DTFA 01-G-015.

Wiegmann, D., Zhang, H., von Thaden, T., Gibbons, A. and Sharma, G. (2004). Safety culture: An integrative review. *International Journal of Aviation Psychology* 14 (2): 117-134. NJ: Lawrence Earlbaum Associates.

Wood, D. C. (1988). Habituation in stentor produced by mechanoreceptor channel modification. *Journal of Neuroscience*, 2254(8).

Yacavone, D. (1993). Mishap trends and cause factors in naval aviation: A review of Naval Safety Center data, 1986-90. *Aviation, Space and Environmental Medicine*, 64, 392-395.

Zhang, H., Wiegmann, D., von Thaden, T., Sharma, G. and Mitchell, A. (2002). Safety culture: A concept in chaos? *46th Annual Meeting of the Human Factors and Ergonomics Society.* Santa Monica, CA: Human Factors and Ergonomics Society.

Zohar, D. (1980). Safety climate in industrial organizations: theoretical and applied implications. *Journal of Applied Psychology, 65*(1), 96-102.

Zohar, D. (2000). A group-level model of safety climate: Testing the effect of group climate on microaccidents in manufacturing jobs. *Journal of Applied Psychology*, *85*(4), 587-596.

Zohar, D., and Luria, G. (2003). The use of supervisory practices as leverage to improve safety behavior: A cross-level intervention model. *Journal of Safety Research, 34*(5), 567-577.